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Production

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Milk, milkborne diseases,
Cow, Dairy plant,
Designated milks,
milk pasteurisation,
milk ~~analysis~~ examination,
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MILK:

PRODUCTION AND CONTROL

BY

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"OLLETT" GOLD MEDALLIST, 1932
PROVINCIAL MILK ADVISORY OFFICER,
MINISTRY OF AGRICULTURE AND FISHERIES

WITH TWO HUNDRED AND ELEVEN ILLUSTRATIONS

SECOND EDITION
(*Reprinted*)

CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE, * MYSORE. *
LIBRARY
1 OCT 1950

LONDON
H. K. LEWIS & Co. Ltd.
1946

First Edition, January, 1936
Second Edition, August, 1946
Reprinted, January, 1948

924

BOOK
PRODUCTION
WAR ECONOMY
STANDARD

THIS BOOK IS PRODUCED IN COMPLETE CONFORMITY WITH THE AUTHORISED ECONOMY STANDARDS

F8, 3c : x5
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CFTRI-MYSORE
924
Milk: Production.

PREFACE

THE problem of the milk supply of this country affects every class of the community and, in so doing, presents innumerable difficulties. In addition to its national magnitude, the milk industry has many facets, each requiring individual consideration. The producer, the distributor, the retailer, the bacteriologist, the chemist, the veterinary surgeon, the medical officer of health, the sanitary inspector, and, last but not least, the consumer—all must be taken into consideration as all have their place in the scheme. Indeed, it is not too much to say that no industry possesses such extensive ramifications, while it is also true that no industry plays a more important part in the national life of to-day.

Milk : Production and Control has been written with a view to presenting the position as it now stands. The subject has received attention in all its aspects, and an endeavour has been made to deal with the problems as they affect each section of the community. It will be found that many points have been repeatedly emphasised, but no excuse is offered for such repetition. This was purposely done, as these points were considered to require the most deliberate emphasis.

No attempt has been made to deal with milk other than as a liquid product. The ancillary uses to which liquid milk may be put are in themselves of such importance as to merit separate consideration.

Criticism has been offered when such was thought advisable. It will be obvious to anyone connected with the milk industry that the present position is far from satisfactory, and, though the opinions expressed by the authors may not meet with universal approval, they have been stated with the sole object of effecting some improvement in present conditions.

In conclusion, the authors would like to express their gratitude to the Controller of His Majesty's Stationery Office for permission to incorporate quotations from Acts of Parliament, from Orders and Regulations, and from other official publications of the Ministry of Agriculture and Fisheries and the Ministry of Health, and to the suppliers of the blocks used to illustrate the text. They also wish particularly to thank J. T. W. Peat, Esq., A.R.I.B.A., Architectural Assistant to the Southgate Borough Council, for the numerous diagrams which he has prepared ; P. B. Tustin, Esq., F.R.San.I. and L. J. Meanwell, Esq., N.D.D. for their kindness in reading the proofs, together with those others who have furnished information made use of in preparing the volume.

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November 1935

PREFACE TO SECOND EDITION

THE reception accorded " Milk : Production and Control " on its first appearance has encouraged the Authors in the belief that a second edition may receive an equally cordial welcome.

The nine years which have elapsed since " Milk Production and Control " was first published have seen a number of changes ; not as many as the Authors would have wished, but then, six years of war have stemmed more progress than one dares to contemplate. None the less, progress has been made, where progress was possible.

The various changes which have taken place in the production and control of our most important foodstuff have been incorporated in this second edition. The Authors hope, and honestly believe, that it represents a picture of the milk industry as it now stands, on the threshold of the post-war future.

It will be obvious that the future holds gigantic possibilities, for good or for ill. If the new edition of " Milk : Production and Control " exerts any influence in moulding future policy, if it succeeds in determining the line which should be taken to remove long-standing, antiquated, even dangerous obstacles, then it will have served a useful purpose. And there the matter must for the moment rest.

W. C. H.
H. H.

February, 1946.

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MILK:
PRODUCTION AND CONTROL

CHAPTER I

COMPOSITION AND FOOD VALUE OF MILK

It is not intended in this volume to deal at any length with the composition or food value of milk, which subjects in themselves call for special consideration. The following summary, however, is supplied, as it was felt that a brief résumé of the situation as it is at present understood was necessary for a proper appreciation of the measures of control essential to the milk industry.

CHEMICAL COMPOSITION

Cow's milk is an amphoteric liquid and is the food designed by nature for the feeding of the calf from birth until the young animal is weaned. It is an opalescent white liquid with a sweetish, palatable taste. No artificial mixture of the substances present in it, if mixed in correct proportions, would yield this liquid. Its principal constituent is water, and in addition it contains fat, sugar, sàlts, nitrogenous compounds, enzymes, and vitamins, together with other constituents. Winter Blyth gives the average composition of cow's milk as follows :

			Parts per cent. by weight.
Water			87·20
Milk Fat	Butyrin	0·15	3·90
	Caproin	0·14	
	Caprylin	0·02	
	Caprin	0·07	
	Laurin	0·29	
	Myristicin	0·79	
	Palmitin	1·00	
	Stearin	0·07	
	Olein	1·37	
The milk fat contains in addition small quantities of cholesterol, phosphatides, glycerol, linoleic acid, and a colouring matter, carotene.			
Milk Sugar (Lactose)			4·75
Nitrogenous Compounds	Casein	3·0	3·40
	Albumin	0·4	
Lactoglobulin, galactin, and fibrin are also present, in traces.			
Ash, derived from the following salts	Sodium chloride Mono-potassium phosphate Di-potassium phosphate Potassium chloride Potassium citrate Di-magnesium phosphate Magnesium citrate Di-calcium citrate Tri-calcium phosphate Calcium citrate Lime combined with proteids		0·75
			100·00

There are also present in milk, vitamins, traces of lecithin, kreatinine, iron, urea, fluorides, acetates, thiocyanates, silica, iodine, odoriferous and bitter principles, and dissolved gases.

In addition to the above-enumerated substances, milk contains a number of enzymes or ferments, which play a part in controlling its fermentation. These are:

(1) Lipase—the fat-splitting ferment which is often the cause of rancid-flavoured milk.

(2) Galactase—this is a protease which curdles and peptonises casein. It is inactivated by heat at 165° to 175° F.

(3) Amylase. Increased quantities of this enzyme are found in milk from diseased udders.

(4) Catalase. A temperature of 150° to 158° F. for thirty minutes will destroy this enzyme.

(5) Peroxidase. Inactivated at a temperature of 158° F.

(6) Phosphatase. Is important in determining the efficiency of pasteurisation.

(7) Reductase.

(8) Diastase.

Oxygen, nitrogen and carbon dioxide are also present, dissolved in the liquor.

The vitamins present in milk are as follows:

(1) **Vitamin A.**—Deficiency tends to produce xeraphthalmia and rickets besides retarding growth in both young and adult. This vitamin will withstand heat. Its presence in milk depends upon the fresh green food which the cow receives, and the amount may be increased by feeding the animal on cod-liver oil. Its provitamin, *carotene*, is responsible for the colouration of the milk fat.

(2) **Vitamin B.** This is the complex vitamen divided into:

(*a*) **Vitamin B_1.** The anti-neuritic vitamin. This vitamin also resists heat, but is not so resistant as vitamin B_2. It is present, along with this latter vitamin, in the milk of cows which receive an adequate diet. Milk is a fair source of this vitamin.

(*b*) **Vitamin B_2.** Sometimes known as vitamin G, this vitamin contains riboflavin and the pellagra preventive factor (nicotinic acid) both of which are present in abundance and the amounts present can be affected by feeding. The anti-dermatitis vitamin, strongly resistant to heat. A deficiency of this vitamin in food may lead to skin disease and lack of normal growth.

(3) **Vitamin C.** The anti-scorbutic vitamin, present also in fresh fruit. This constituent of milk is relatively constant throughout the year, but it should be emphasised that milk does not contain a sufficient quantity to supply the entire needs of the body and further sources of supply such as fruit and green vegetables must be considered as essential requirements of the human diet. Cows feeding on green pastures give milk somewhat richer in this vitamin than cows fed on cake. It is very sensitive to heat and oxidation, and its absence in the diet gives rise to scurvy and abnormal tooth and bone formation.

(4) **Vitamin D.** The anti-rachitic and calcifying vitamin which is heat stable and which possesses a provitamin, *cholesterol*. Its quantity in milk is increased by sunlight and green food. Milk cannot be relied upon to provide a sufficiency of vitamin D as it is definitely deficient in milk when the cow is receiving a winter feed of roots and concentrates and is not exposed to sunshine. Bone disease, rickets, and defective teeth result from its absence. Its presence in milk may be increased by irradiation (by ultra-violet rays) of

the cow or of the milk. It can be increased in milk by feeding the cows on cod-liver oil.

(5) **Vitamin E.** The vitamin which is claimed to hold relationship to the functions of reproduction. Although this has been proved as regards animals, no definite proof has yet been forthcoming in this respect as regards human beings. It is unaffected by heat.

Before the present War, a German scientist, Dr. Müller Lenharts, of Leipzig, claimed to have discovered a new vitamin in milk to which he had given the name " M." He stated that this vitamin was allied to vitamins A and D whose action it supported and its main functions were similar.

Milk Fat

The milk fat or butter-fat is present in the form of small globules of different fats of low melting points in suspension, and varies in amount according to the breed of cow supplying the milk. The larger the globules are, the more quickly does the fat rise. On an average, 60 per cent. of fat rises to the surface if milk is allowed to stand eighteen hours and this tendency to rise is accelerated by heating. The fat furnishes the body with heat and energy, and contains most of the colouring matter, known as carotene. It is the primary source of vitamins A and D.

Water

As already stated, this makes up the bulk of the milk, and can be separated from the solids by evaporation.

Proteins

These substances are not present in milk in true solution, but are in colloidal suspension. They can be separated from the soluble constituents of milk by a porcelain filter. The principal proteins are casein and lactalbumen, the latter causing the " skin " to form on milk when it is heated. They possess a high nutritive value since the amino acids of which they are composed make them suited for the requirements of growth in the young and of maintenance in the adult. Lactoglobulin, galactin, and fibrin are also present in small quantities.

Milk Sugar or Lactose

This exists in solution, and can be separated from the whey by the evaporation of the water and subsequent crystallisation. Its composition is similar to that of cane sugar, but it is much less sweet. It readily ferments by the action of the lactic acid bacteria, forming lactic acid, which is the primary cause of the souring of milk. This substance furnishes heat and energy to the body.

Mineral Matter or Ash

Mineral matters in milk exist in solution or in combination with casein. The ash forms only a small percentage of the whole, and is made up of a large number of salts, especially calcium salts and phosphates. Milk is relatively deficient in iron salts. When milk is heated to high temperatures, some of the salts are thrown out of solution. The mineral matters supply the constituents which assist in the formation of bones and teeth.

Variations in Composition

There are certain variable factors which affect the composition of milk both as regards fat and solids-not-fat content, but as these are dealt with specifically in Chapter III, brief mention will only be made of them at this point. These factors are :

(1) **Breed of Cow.** Heavy yielders generally give milk with a low fat percentage, while those giving milk with a high fat percentage are usually poor yielders. This does not mean that the total yield of fat from a heavy yielder is low as the yield of milk varies with the breed. It is, however, really a question of selective breeding. With a rising yield, the percentage of lactose increases.

(2) **Feeding.** Unsatisfactory feeding is the commonest cause of low yield. It is necessary to feed, not only to maintain the bodily needs of the cow, but also to assist production. With inadequate rations, the animal has to draw upon its body tissue to make up any deficiency. Minerals introduced into the food assist to increase the yield and are usually incorporated in feeding compounds which, if fed according to yield, will satisfy the animals' requirements.

(3) **Seasonal Variations.** Owing to a variety of circumstances, the composition of milk varies with the seasons. Winter milk is usually richest in fat, while summer milk is greatest in quantity.

(4) **Health of the Animal.** Ailing animals give reduced yields of milk.

(5) **Age of the Animal.** Cows of four to seven years of age are the richest milkers. The average life in the herd of a dairy cow is approximately four and a half years.

(6) **Efficiency of the Milker.** Inefficient milkers may cause an animal to withhold its milk, just as inefficient stripping is the common cause of the early drying off of animals. Strippings or last-drawn milk may contain as much as 9 per cent. of fat, and it is therefore essential that animals should be properly stripped.

(7) **Intervals between Milking.** Equal intervals are to be preferred, but this is not always possible. Morning milk is usually greatest in quantity but poorest in fat.

(8) **Period of Lactation.** Too frequent lactations should be avoided, and an adequate rest should be allowed between each lactation period.

(9) **Individuality of the Cow.** Individual cows of similar breeds often show great variations in the quantity and quality of the milk produced. Variations in fat percentage up to 1 per cent. have been observed.

Much of the milk at present sold is abnormally low in fat, although not under the legal standard, while in addition it is often low in lactose, casein, calcium, and phosphates, the missing substances being replaced by sodium chloride or common salt. This is probably due to continued breeding for high yields. There has, up to the present, been little inducement to farmers to produce milk of high quality, as in the majority of cases, provided the fat percentage satisfies the legal standard, no better price is received. It is necessary for those producers who wish to obtain high-quality milk to remove cows which give low-quality milk from the herd, and add animals producing milk which show a satisfactory fat percentage. For this reason a few Jersey or Guernsey cows are often brought into herds to maintain or raise the quality of the general supply, this being a very desirable proceeding.

Cellular Content of Milk

In addition to its chemical constituents, milk contains cellular elements which are to be found even in the secretion of healthy animals, although the number of such cells and their types vary. The cells separate from the linings of the teat canals, milk ducts, and milk cisterns, although some may gain entrance to the milk via the external surface of the udder and teats. The cellular content of milk is often a useful indication of disease in the udder which may or may not be responsible for human infection, but such a cell count is not a definite proof of diseased conditions, as the cellular content of milk may show a distinct variation from one healthy cow to another. The age of the animal may be another factor affecting the number of cells present. Experiments have shown that there is a marked tendency for the cellular content of milk to increase as the age of the cow increases. Generally speaking, a sample of milk which contains more than 200,000 body cells per millilitre almost invariably comes from an abnormal or diseased udder. A cell count is of most value when used in conjunction with other examinations.

Savage classifies the cellular content of milk as follows :

(1) Polymorphonuclear cells.
(2) Large cells, varying in size.
(3) Leucocytes, varying in size.

He discovered, in the course of his researches, that the following factors produced a high cellular content :

(*a*) Milk of cows a few days after calving showed a marked increase in the cellular content, the increase being shown chiefly in the leucocytes.

(*b*) The milk of cows in the later stages of pregnancy showed a rise in the number of large cells.

(*c*) The milk of cows drying off showed a high cellular content.

(*d*) High cellular counts were often due to mastitis and other diseased conditions of the udder.

Red blood cells are also sometimes found in milk.

Great variations in the number of cells present in milk occur, not only in milk from different sources, but also from different animals with day to day variations while the period of lactation exerts a similar effect. Variations occur in the milk from separate quarters of the udder and in different portions of the milking. The strippings show a higher cell content than either the fore or middle milk, which phenomenon may be due to the manipulation of the udder during the stripping process.

FOOD VALUE OF MILK

The milk of all animals is liquid when consumed, but solidifies to a curd when entering the stomach. This coagulation causes part of the proteins to be retained in the stomach until absorption takes place. Milk protein, which has a high biological value in enhancing simple vegetable foods taken in conjunction with it, is specially adapted for this purpose.

Cow's milk is the perfect food for calves until they are weaned, as it contains all the food constituents required for healthy development and it occupies an almost unique position amongst foods in that it is designed and elaborated to satisfy the nutritive demands of rapid growth. For infants, however, cow's milk is too rich in protein and contains too little sugar. For this reason a little sugar must be added before such milk is fed to infants, while the protein content should be modified to render the product similar to human milk in composition. Containing as it does 87 per cent. of water, milk is too bulky for older children and adults to rely upon for all the nutrition they require, as its food constituents are too diluted. Regardless of these faults, milk can still be said to be the most nearly perfect nutriment for all ages.

Food must fulfil many requirements if it is to maintain healthy life. For those persons in fairly good circumstances, a sufficient variety of food can readily be purchased, but less affluent families are often limited in their choice of food through economic reasons, the result being that their children may suffer from under-nourishment. When the variety is restricted, the selection of food requires the greatest care. At no stage in its existence is the body entirely at rest. Wear and tear is constant, this activity being increased when the body is at work or is exercising. Food of the right kind is essential to healthy growth and for the maintenance of bodily vitality, but it is also essential that such food should be thoroughly digestible, so that the nutriment obtained can be quickly and easily distributed throughout the body.

Food, to be nutritious, must contain the following compounds in varying quantities :

(1) Proteins (Nitrogenous Compounds). Easily digested protein is essential for body building.
(2) Fats.
(3) Sugar Constituents. These are essentially heat and energy producers.
(4) Mineral Matter (Salts). Calcium and phosphorus salts are essential for the growing tissues of the body.
(5) Vitamins. These are necessary for normal growth.

A certain amount of liquid must also be taken.

Food must not only possess all these constituents, but they must also be present in well-balanced proportions if the food is to be of any value. Milk is in itself complete, as it contains the necessary constituents in well-balanced proportions, including a supply of each vitamin yet discovered. The digestibility of milk varies with the individual, but it is generally considered to be 95 per cent. digestible to the average person. Not only is it a suitable form of diet, but, in relation to other common articles of food, it is also economical, as is shown below :

One quart of milk is equal in food value to
Approximately 1 lb. lean meat.
4 lb. cabbage.
10 eggs.
2 lb. potatoes.
Over 1 lb. chicken.
5 lb. turnips.
Approximately 2 lb. sole.
3 lb. codfish.

One large glassful of milk is equal to 2 eggs in food value while 1 pint of milk supplies seven-eighths of the calcium, over one quarter of the protein, slightly less than one-third of the riboflavin and over one-fifth of the vitamin A which nutrition experts recommend for a moderately active man. It is specially valuable to the young in that it contributes more largely and more uniformly to their well-being. One pint of milk supplies one-seventh of the adult's daily needs and one-third of the child's requirements.

Milk is a good tooth and bone builder, as it is exceptionally rich in calcium, present in a form in which it can be easily utilised by the body. It is a much more concentrated food than is sometimes thought, milk being often considered a liquid with a consistency little better than water. It averages approximately 13 per cent. of solid matter, which is considerably more than is the case with many vegetable foods, such as carrots, onions, tomatoes, celery, and cabbage. Milk contains all the known vitamins in varying proportions, and, as a source of vitamin A, is the most important of all our foods. This is of special import, as most of our staple foods are deficient in this vitamin. Milk is also a good muscle builder, as it is rich in protein, which is necessary for the formation of strong muscles in children and for the good health of the adult.

The consumer often fails to understand that milk is a beverage with a high food value, looking upon it merely as a means of improving the taste and appearance of tea, coffee or cocoa, or perhaps as a food for the rearing of infants ; even this is not always the case, judging by the number of tins of condensed milk sold in this country, more especially in the industrial and poorer districts. It is, in fact, astonishing to discover the number of people who do not buy any liquid milk except for the making of an occasional milk pudding.

As milk is cheap in comparison with other foods, its consumption should be considerably increased. Its value as a food has been practically demontrated by a series of experiments carried out by Dr. H. C. Corry Mann which are universally quoted as evidence of its remarkable food value to children. In a large boarding school he divided the boys, whose ages varied from six to eleven years, into seven groups, the daily diet of each group being as follows :

Group 1. Daily Diet.
Group 2. Daily Diet + 1 pint of milk daily.
Group 3. Daily Diet + additional sugar.
Group 4. Daily Diet + additional butter.
Group 5. Daily Diet + additional margarine.
Group 6. Daily Diet + additional casein.
Group 7. Daily Diet + additional water-cress.

Accurate observations were kept over a period of twelve months. At the end of this time the gains in height and weight of each boy in each group were recorded and compared. It is not necessary to give the results of the last five groups, but only to compare those fed on normal diet with those fed on normal diet plus milk. This latter group gave some remarkable results. The boys on normal diet gained on an average $3\frac{3}{4}$ lb. and grew an average of $1\frac{3}{4}$ inches per boy in twelve months. Those who had received the extra pint of milk gained on an average 7 lb. and grew an average of $2\frac{5}{8}$ inches per boy over the same period. It was also noticed that the increased gain in height and weight was accompanied by improved health and spirits.

Another experiment, carried out by the Scottish Board of Health under the supervision of Dr. Boyd Orr, confirmed the result obtained by Dr. Corry Mann. The children here numbered 1,400, and were attending public elementary schools in seven large towns. Their ages ranged from five to fourteen years, and they were arranged in four groups. The groups and diets were as follows :

Group 1. Ordinary home diet.
Group 2. Ordinary home diet + milk.
Group 3. Ordinary home diet + separated milk.
Group 4. Ordinary home diet + a biscuit with the same energy-yielding value as separated milk.

The experiment extended over a period of seven months, and at the end of that time it was found that those children who had received whole milk in addition to their normal home diet showed an increase of 20 per cent. in height and weight over those who had not. This increase was also accompanied by improved general health. It was found that separated milk was a good promoter of growth.

Another large scale experiment was carried out in Luton, Wolverhampton, Burton-on-Trent, Huddersfield and Renfrewshire between February 1935 and July 1936. Over 8,000 children participated and these were divided into four groups, viz.:

Group 1.	"Controls" who received biscuits.
Group 2.	These children received $\frac{1}{3}$ pint pasteurised milk.
Group 3.	do. do. $\frac{2}{3}$,, do. do.
Group 4.	do. do. $\frac{2}{3}$,, raw milk.

All the milk and biscuits were supplied free of cost. The report of the experiment shows the great value of milk to growth and health. It was found that those children who had one-third of a pint of milk showed greater improvement in physique, general health and in scholastic ability over those who had taken biscuits, while the increases in those taking two-thirds of a pint of milk was still greater. This experiment also showed that there were no consistent differences between the growth of those who had raw milk and those who had pasteurised milk.

Fresh foods are always to be recommended, and such foods should be free from preservatives. No preservatives are allowed in milk, and the freshness is readily gauged, as any lack of this quality is disclosed by souring. The Ministry of Health Advisory Committee on Nutrition was so firmly convinced of the value of milk as a food that it recommended that at least 1 pint per head per day should be taken by each child under sixteen years of age, about 2 pints per day for expectant mothers and at least $\frac{1}{2}$ pint per day for the rest of the population.

To sum up, one cannot do better than quote the words of Sir George Newman, who says:

> " The peculiar importance attached to milk as an item of daily diet lies in its capacity for making good and restoring the balance of the various essential constituents required for adequate nourishment which is so often upset by ignorance or prejudice, or by actual restrictions in the matter of choice."

Milk for Schoolchildren

The results of the experiments previously quoted show that milk is a necessity in the diet of any child. There is a tendency for mothers to reduce the quantity of milk in summer, as they believe that a lesser amount of food is required during hot weather. This is no doubt true up to a point, but in summer the child expends a greater amount of energy, while growth is also increased. In hot weather light, easily digested foods are specially called for, and milk fulfils these conditions ideally, while being in every way suitable for maintaining the vitality of the child during this period.

Most members of the medical profession speak of milk as a valuable source of nutriment for growing children. Careful observations have shown the great effect of extra milk on the general development and on the mental and physical well-being of such children. School medical officers and teachers are enthusiastic about the nutritive value of milk, and state that it is an important factor in maintaining good health in children. The Ministry of Agriculture and the Milk Marketing Board during 1934 brought forth a scheme to ensure that more children should have milk regularly than was possible under the old Milk in Schools Scheme, sponsored by the National Milk Publicity Council, which provided milk in a great many schools at the cost of one penny per child per day. Schoolchildren are now supplied with one-third of a pint of milk daily at a cost of one halfpenny or twopence halfpenny per week, although by far the greater number are now drinking two-thirds of a pint daily. The reduction in cost increased the present consumption of milk in schools enormously, and those children who were unable to afford this small charge—and unfortunately far too many fell within this category—could receive their milk free of charge on the certificate of the school medical officer. The cost of this free milk was borne by the local Education Authority. Since the inception of the Milk in Schools Scheme in October, 1934, there has been a steady increase in the number of children obtaining such milk and almost every school in the country is participating in the scheme at the present time. Large quantities are now consumed by schoolchildren to their great benefit and the benefit of the future community.

The provision of milk for schoolchildren is teaching them the habit of milk drinking, which habit will, it is hoped, continue in later life, and be passed on to future generations. Apart from this, the scheme has provided a new outlet for surplus liquid milk, which will prove a good advertisement for the industry and be of great assistance to it.

Before the Milk Marketing Board Scheme of milk distribution to schoolchildren had long been in force, various objections were made to it, mainly on the grounds that children became sick after drinking the milk. This was to be expected, when one remembers that many such children had never before drunk milk in any quantity together with the known habit of " gulping " prevalent even among normal young persons. Education and supervision have quickly eradicated this fault, which ought not to be held against the known advantages of the scheme. On the other hand, it is fallacious to suggest that milk should be sipped slowly instead of drunk naturally in order to ensure proper digestion. Milk taken very slowly forms a larger curd in the stomach and consequently takes longer to digest.

Consumption of Milk

This country cannot be rated very highly in the quantity of milk consumed per head per day. According to the latest available statistics, the daily consumption of milk per person in various countries is as follows :

Finland	1·75
Denmark and Sweden	1·50
Switzerland	1·25
United States	1·00
Scotland	1·00
Austria	1·00
Canada	0·75
Germany	0·66
England (War-time)	0·60
France	0·50
Italy	0·25

In this country before the war the consumption of milk varied considerably from week to week and from district to district. There was a greater demand for milk at week-ends, some areas showing an increase of 10 per cent. Extremes of weather also gave rise to variations, increases being noticeable during inclement weather, when people were forced to forego their week-end outings. In poorer-class districts, the average consumption per head per day was often less than $\frac{1}{4}$ pint, while in better-class and rural areas it was generally much more. Further variations in districts were noted, often due to reduced purchasing power and the lack of knowledge of dietetic standards. Large seasonal variations occurred during summer, due to the movements of holiday-makers. The rationing of milk, consequent upon the outbreak of war and the shortage of supplies has resulted in the demand for the full minimum ration which is now fixed at 2 pints per week for an adult, ½ pint per day between the ages of five and eighteen years and 1 pint per day up to the age of five years. These amounts are subject to variatious as seasonal increases in supplies occur. The *Cheap Milk and Free Milk Schemes*, of the Ministry of Food, have also been of considerable assistance in maintaining the health and well-being of necessitous persons. More than 80 per cent. of nursing and expectant mothers and children under five receive 1 pint of milk a day, either free or at a much reduced price.

England was never a milk-drinking or milk-using country, and milk had no place among the beverages consumed by the adult population. It was not commonly regarded as a food except for infants and invalids. Frequent attacks, which were often and still are justified, have been made by the medical profession on the hygienic quality of milk, and these, without doubt, affected the consumption. Propaganda was ably carried out by the National Milk Publicity Council and the Milk Marketing Board to increase consumption. Before such propaganda could show effective results and the consumption of milk be increased the present war came and with it the rationing of supplies as mentioned above. Before milk consumption can be increased after the war terminates, the public must feel confident that the milk they purchase is both clean and safe. The more milk which is consumed, the lower will be the cost of distribution. If the saving in distribution costs is passed on to the consumer, as ought to be the case, an increased demand will result. The matter will be in the hands of the industry, and any effort which they may make will be of benefit to all concerned.

Although England is low in the scale of milk-consuming countries, the magnitude of the industry will be realised when the following figures are considered.

Before the war the total valuation of tangible assets used directly in the production, transport, processing and distribution of milk amounted to nearly £400,000,000. At the present time there are now nearly 160,000 milk producers while the number of persons employed by them is round about 300,000. Another 150,000 are engaged in transport, processing and distribution, giving a total employment in the industry of approximately 450,000 persons. Eighty-five per cent. of the cows in this country are at present used as milk producers. These herds may be divided as follows:

36 per cent. containing less than 10 cows.
45 ,, ,, between 10 to 25 cows.
15 ,, ,, ,, 25 to 50 cows.
4 ,, ,, over 50 cows.

The effort of one man backed by £100 to £150 of capital is required to produce and bring one gallon of milk to the consumer. During 1942–43. over 1,100,000,000 gallons of milk were produced and sold, of which by far the greater proportion was disposed of as liquid milk.

These figures clearly demonstrate the magnitude of the industry and the definite necessity for the strictest measures of control.

CHAPTER II

MILK AND DISEASE

Bacteria found in Milk

It has already been stated that cow's milk is an almost perfect food for human beings and is the perfect food for calves. This perfection, however, is in itself a source of weakness, as the food value of milk enables it to support bacterial life which, under favourable conditions, flourishes with rapidity. Bacteria are the smallest form of life. Some idea of their size may be gained from the fact that it has been calculated that 42,000,000,000,000 milk bacteria in moist condition would weigh only one ounce. They are practically universal and, when pathogenic in type, produce the majority of diseases to which man is subject. When these organisms attack any matter, they produce putrefaction, fermentation, or chemical change. They require food and moisture to allow of growth and, if gentle warmth is present in addition, their increase is rapid. Alternatively, refrigeration deters their multiplication. Bacteria multiply in different ways. In some cases they increase in length or size and multiply by fissure. Other bacteria form spores, which develop at a later date into adult organisms. A small number of bacteria will, in a few hours, multiply to many times their original number under favourable conditions.

Milk from the udder of a healthy cow contains very few organisms, certainly not more than 300 per mililitre, and these are of no danger to the consumer. After production, the liquid undergoes a phase when the bacterial content does not increase but may be reduced. If diseased conditions prevail, however, bacteria may be present in large numbers, although it should be stated that entrance to the milk is generally gained *after* production. Despite their minute size, bacteria can accomplish a great deal in various directions. It has been proved that lactic-acid organisms, which are present in milk in varying numbers even when produced under clean conditions, can consume their own weight of food each hour. They absorb food over their entire surface and emit waste products, generally acids, into the milk. Some, however, do not affect the milk in any way, remaining neutral. Lastly, some bacteria, such as the lactic-acid-producing organisms, check the growth of the more injurious bacteria which may find their way into the milk, and are in that respect useful parasites.

The bacteria present in milk may be separated into two groups :

(1) Pathogenic.
(2) Non-pathogenic.

(1) Pathogenic Bacteria

Apart from the non-pathogenic organisms found in milk, there are those whose presence is capable of producing disease in the human subject. These may produce no immediate visible effects and can only be discovered by a laboratory examination of the milk. They may be divided into two classes :

(*a*) Organisms of Animal Diseases.
(*b*) Organisms of Human Diseases.

(*a*) **Organisms of Animal Diseases.** Any diseased condition of the animal may be responsible for the entrance of organisms into the milk in varying proportions. The following organisms of diseases which have their primary origin in cattle have been found in milk :

(1) *Mycobacterium tuberculosis* (Bovine).
(2) *Brucella abortus.*
(3) *Streptococcus mastitidis, Bacillus pyogenes,* and *Staphylococci* associated with Mastitis.
(4) *Bacillus anthracis.*
(5) *Virus of Foot and Mouth Disease.*
(6) *Virus of Cowpox.*
(7) *Actinomycoses* (Parasitic Fungi).
(8) *Bacillus enteritidis of Gaertner.*

(*b*) **Organisms of Human Disease.** Whilst these organisms owe their primary origin to human infection of the milk supplies, the udders of the animals may also be affected from human sources. The organisms of the following diseases have been found in milk following infection from human sources :

(1) Typhoid and paratyphoid fever.
(2) Dysentery.
(3) Diphtheria.
(4) Scarlet fever.
(5) Cholera.
(6) Septic throat.
(7) Tuberculosis of human origin.
(8) Infantile diarrhœa.

It should be stressed that, although milk may be produced under hygienic conditions and have a low bacteria count, it may still be dangerously infected with pathogenic organisms.

(2) Non-Pathogenic Bacteria

It is fortunate for consumers of milk that the non-pathogenic organisms considerably outnumber the pathogenic group. The main types of non-pathogenic organisms found in milk are the lactic-acid-producing bacteria, spore-forming organisms, and other bacteria causing abnormal conditions, mainly colour changes. The lactic-acid organisms account for some 85 per cent. of the total number of bacteria present in milk. The organisms responsible for the production of lactic acid are :

(*a*) *Streptococcus Lactis and Staphylococci.* The presence of these organisms provides a valuable guide to the age of the milk, as their presence, when excessive, renders the milk unsaleable. They are found in souring milk residues, on the skin of the cow's udder and teats and in cow dung.

(*b*) *Micrococci.* These are usually slow acid formers, and grow over a wide range of temperatures, while, in addition, they may have proteolytic properties.

(*c*) *Bacillus coli* }
(*d*) *Bacillus aerogenes* } These indicate manurial pollution.

(*e*) *Bacteria of the Saprophytic group.*

(*f*) Numerous organisms of unknown identity, together with acid-fast organisms, principally *smegma bacilli.* The fact that acid-fast bacilli other than tubercle bacilli may be present in the milk is an argument in favour of biological rather than microscopical examination of milk. This will receive more detailed attention later.

The spore-forming organisms include :

(*a*) *Bacillus putrificus.*
(*b*) *Bacillus Welchii.*

he bacteria causing abnormal colour conditions in the milk (known as the hromogenic group) are principally :

- (*a*) *Bacillus prodigiosus.*
- (*b*) *Bacillus cyanogenes.*
- (*c*) *Bacillus fluorescens.*
- (*d*) *Bacillus erythrogenes.*
- (*e*) *Bacillus violosis.*
- (*f*) *Bacillus synscantha.*
- (*g*) *Torula glutenis.*

The acid-producing organisms cause an alteration in the character of the milk which ends in putrefaction. The factors which decide the rate of this change are

- (*a*) The quantity originally present in the milk.
- (*b*) The temperature at which the milk is kept.

If milk with a high bacterial content is kept above a temperature of 60° F., conditions are favourable for early and rapid souring. The *Streptococcus lactis* grows well at temperatures down to 45° F., and for this reason milk should be stored below this temperature in order, at least, to retard bacillary action. The spore-forming organisms, which are mostly anaerobic in character, do not multiply very rapidly in milk, as it is constantly in contact with air and contains quantities of oxygen in solution. The chromogenic organisms, responsible for taints, flavours, and alterations in character, are generally of external origin. Economically their presence is to be deplored, since by their action the milk is rendered unsaleable, but they are otherwise of comparatively little importance. The saprophytic organisms render the milk, which is already a perishable article, more perishable, and they are therefore a source of loss to the producer and distributor. Their presence in large numbers is also an indication of faults or carelessness in production.

Sources of Bacterial Infection

The origin of the human *pathogenic* bacteria found in milk is almost invariably human infection received during the handling of the milk, or the udder of the animal, which has in turn been infected by human agency. Of the diseases affecting the animal, the causative organisms of which may find their way into the milk, the chief is bovine tuberculosis, the primary source of which is the cow suffering from tuberculosis of the udder either in its early or advanced stages. Sputum expectorated by the affected animal or infected fæces or urine may also contaminate the milk. Other diseases of cattle add their organisms either directly or indirectly to the milk. *Brucella abortus* may be added through discharges which soil the tail of the animal, and other pathogenic bacteria may find a similar way into the milk. Organisms pathogenic to man may develop in cuts and ulcers on the teats of the cow. Cows suffering from intestinal disorders have been the means of infecting milk with the *Bacillus enteriditis of Gaertner*, such infection occurring owing to the contamination of the milk by infected fæces.

The sources of *pathogenic* bacteria in milk may be summarised as follows :

(1) The Animal Itself

(*a*) *The Udder.* Diseased conditions in the udder may be responsible for the presence of pathogenic organisms in the milk.

(*b*) *Ulcers on Teats and Udder.* Such ulcers form a suitable nidus for any pathogenic organisms, which obtain entrance from the hands of the milker, subsequently entering the milk during milking operations.

(*c*) *Animal's Coat, Fæces or Urine.* Infected fæces, urine, or other discharges may contaminate the coat of the animal and subsequently obtain entrance to the milk.

(2) **Persons Handling Milk**

(*a*) Direct infection may occur during milking or handling of the milk by persons suffering from disease or by "carriers" of certain diseases. Infected hands and mucus of milkers and dairy workers are also possible sources of contamination.

(*b*) Infection of utensils and equipment by persons handling or washing such equipment may occur.

(3) **Infected Water**

(*a*) Water used for cooling purposes is a potential source of danger when, owing to a faulty cooler, such water may gain access to the milk.

(*b*) Infection of utensils and equipment may occur by washing with infected water.

(4) **The Air of the Cowshed or Dairy**

Milk may be contaminated by pathogenic organisms in the air of the cowshed or dairy, such organisms being exhaled by infected animals or workers.

(5) **Fly Infection**

The contamination of milk by flies is very common, and in this manner pathogenic organisms of various types may be carried into the milk. The principal organisms transmitted in this way are those causing typhoid, paratyphoid, tuberculosis, diphtheria and anthrax and such organisms can exist on flies for long periods.

(6) **Infection in the Home**

The infection of milk in the home by pathogenic organisms is possible in various ways. Infected persons drinking milk directly from the jug or bottle in which it is contained may cause further supplies of milk from the same container to be contaminated.

The sources of contamination of milk by *non-pathogenic* organisms are many and varied. It may be generally accepted that the organisms of the *B. coli* and *B. aerogenes* groups are generally of intestinal origin, and find their way into the milk from excretions and bedding, although instances have been known of coli organisms being present in the milk when drawn from the udder. *B. aerogenes* is also commonly found in herbage. The acid-producing organisms gain access to the milk from a variety of sources, of which the udder itself is one. Streptococci and micrococci are found to be distributed in many ways, and obtain entrance to the milk from various sources, e.g. the animal's coat and udder, the air of the cowshed, the milker's hands, together with improperly cleansed strainers, coolers, and receptacles.

The sources of contamination by non-pathogenic organisms thus closely resemble those already enumerated in the case of pathogenic organisms, and may be summarised as follows :

(*a*) **Contamination from the Udder**

In this connection the milk of some cows has been proved to have a larger bacterial content than others. This may have an effect on the bacterial count of samples if the herd contains a few such animals which regularly give milk of this nature. The milk drawn from some quarters contains more bacteria than that from others. The age or feeding of the animal does not appear to affect the bacterial content of the milk in any way. The foremilk contains the greater number of bacteria, and should be discarded.

(*b*) **Contamination from External Sources**

(1) *The Air of the Cowshed.* Brushing and feeding the animals immediately prior to milking is likely to increase the number of bacteria present in the air of

he cowshed, with a consequent increase in their opportunities of gaining access o the milk.

(2) *The Utensils.* The various utensils, if not properly cleansed and sterilised mmediately after use, if improperly stored, or of unsatisfactory design, will ncrease the bacterial content of the milk contained therein.

(3) *The Coat of the Animal.* This source of contamination consists mainly f dirt made up of dried manure, dandruff, and hair which carries considerable umbers of organisms. Efficient grooming and washing are therefore essential.

(4) *The Milker.* Milkers may add organisms to the milk from dirty hands and clothing, and from sneezing or coughing over the milking-pail. Wet milking is a certain source of pollution in this respect, while unsterilised milking machines will also assist in contaminating the milk.

(5) *Miscellaneous Sources.* Accidents to utensils, causing them to become contaminated, such utensils being used without further sterilisation, together with contamination of the milk by flies, are the chief miscellaneous sources.

(*c*) Contamination after Production

(1) *Strainers.* These can add very considerably to the number of bacteria if not properly cleansed and sterilised.

(2) *Coolers.* The number of bacteria present may be rapidly increased by inefficient cleansing due to defective design or by leakage of polluted water into the milk.

(3) *Churns.* Inefficient sterilisation, due to faulty design or improper methods, will invariably result in an increased bacterial content.

(4) *Bottles and Bottle Caps.* Dirty, inefficiently sterilised bottles and dirty bottle caps and discs used for sealing purposes form certain sources of contamination.

(5) *Bottle-filling Machines.* Want of proper cleansing is the main source of danger.

(6) *Pasteurisation.* Inefficient or dirty methods of uncontrolled pasteurisation must at all costs be avoided.

(7) *Dairy Employees.* Dirty clothing and hands, and sneezing and coughing over milk which is uncovered should never be permitted.

(*d*) Contamination in the Home

Contamination of milk very often takes place after it has been safely delivered to the consumer. Considerably more educational work is necessary among consumers to ensure that, if and when they are supplied with clean milk, they understand the proper method of keeping the product sweet and clean. Improper storage methods in the home and contaminated receptacles are the chief means of increasing the bacterial content of milk after purchase

In order to safeguard against undue bacterial contamination of milk, it is obviously necessary to prevent bacteria gaining access to the liquid. The methods which should be used to attain this object are detailed more fully in later chapters, so that it is only necessary at present to mention briefly the essential measures. These may be set out under three headings, as follows :

(1) Prevention of contamination at the farm.
(2) Prevention of contamination during distribution.
(3) Prevention of contamination in the home.

(1) Prevention of Contamination at the Farm

(*a*) Elimination of foremilk.
(*b*) Elimination of cows regularly giving milk with high bacterial counts.
(*c*) Prevention of dust in the air of the cowshed.
(*d*) Proper care of utensils, such as coolers, strainers, milking machines, pails, and stools.
(*e*) Healthy animals.
(*f*) Cleaning of cows—clipped udders and flanks.
(*g*) Use of narrow-mouthed pails.
(*h*) Proper methods of milking.
(*i*) Cleanliness of the milkers—clean hands and clean clothing.

(2) Prevention of Contamination during Distribution

- (*a*) Proper handling of the milk.
- (*b*) Care and cleanliness of utensils and apparatus.
- (*c*) Bottling of the milk.

(3) Prevention of Contamination in the Home

- (*a*) Proper storage.
- (*b*) Clean receptacles.

It is apparent that the prevention of the entry of large numbers of bacteria to milk is only a matter of method and cleanliness at each stage of its journey from the cow to the consumer. The main points which it is necessary to observe are :—

1. Clean, healthy animals.
2. Clean, healthy milkers.
3. Clean utensils.
4. Clean surroundings and handling at all stages.
5. Clean and satisfactory storage in the home.

The Behaviour of Bacteria in Milk

The growth of bacteria is entirely determined by the initial number present in the milk and by the temperature at which the milk is retained after production. It has been found that, after milk is freshly drawn from the udder, there may be a decrease in the number of organisms present, which decrease is said to be due to the germicidal action of the milk. Heating will destroy this germicidal action, but the temperature at which the destruction occurs varies. The cause of this decrease is dependent upon several factors, and it is suggested that not only do the agglutinins and antibodies present in milk affect the numbers, but also that the cellular content of the milk continues to exert a phagocytic action after the milk has been drawn. Temperature has a profound effect. At or below the freezing-point of milk (about 31° F.), there is no multiplication of bacteria. There is indeed a tendency for their numbers to be decreased, but the rate of such decrease depends upon the resistance of the organisms to the existing conditions. At 32° F. a slight decrease in the number of organisms is shown, but after a week they commence to multiply until large numbers are again present. At a temperature of 40° F. the changes are similar to those in milk held at a temperature of 32° F., except that they occur much earlier. At 50° F. the changes are variable, due to the fact that certain organisms find this temperature favourable for their growth. In some milks acid develops to a considerable extent, while in others fermentations take place. Seventy degrees F. sees the rapid development of the lactic-acid organisms, principally the *Streptococcus lactis*. At subsequent temperatures up to 100° F. production of acid and gas takes place very rapidly. The effect of variations in temperature may be summarised as follows :

(1) The effect of temperature upon the growth of the various bacteria is always the same under similar conditions.

(2) There is a period immediately after milking when no increase takes place in the number of bacteria in the fluid and when an actual decrease may occur.

(3) The preliminary quiescent period is invariably followed by a period of multiplication. Different types develop, so that samples of milk kept at varying temperatures may differ in their bacterial content, although the total count may be the same.

(4) Rapid growth of the lactic-acid organisms is followed by a decrease in the number of other bacteria present.

The thermal death-points of the principal pathogenic organisms found n milk are as follows :

M. tuberculosis	140° F. for 20 minutes.
Br. abortus	140° F. for 15 minutes.
B. typhosus, paratyphosus, and enteritidis	140° F. for 5 minutes.
C. diphtheriæ	140° F. for 3 minutes.
B. dysenteriæ	140° F. for 10 minutes.
Streptococci	130°–145° F. for 5 minutes.

MILK-BORNE DISEASES

There have been many outbreaks of disease due to infected milk in the past, and there is still no reason to believe that more will not occur in the future. When the quantity of raw milk consumed daily is considered, the number of epidemics due to infected milk is very small. This must not be taken as an indication or as an excuse for slackness, as the issue is much too great to allow of any permissible standard short of the optimum. Authorities should not rest from their labours until the likelihood of a milk-borne epidemic occurring is nil, and until the even greater danger of tubercular infection is finally abolished.

Before dealing with the question of infection due to milk, the *characteristics of a milk-borne epidemic* should be stated. These are very briefly as follows :

(1) The outbreak is usually explosive in character, although this does not always hold. A number of cases will be notified at the same time, these primary cases being in turn responsible for secondary infections. Two or more cases may develop in one family on the same day. After the first cases are notified, further notification will be received from day to day.

(2) Investigation will show that a large number of the affected families obtain their milk from the same producer or distributor. If the milk consumed by the affected persons is all obtained from one source, suspicion will immediately point to the vendor of such milk. The fact that all the consumers of an infected milk are not affected may be accounted for as follows :

(*a*) The possession of a certain degree of immunity to the specific infecting organism by some consumers of the affected milk.

(*b*) The fact of the milk having been heated before being consumed. This is a common practice in many homes.

(*c*) The fact that all the milk does not contain the infecting organisms.

(3) The incidence of infection is higher in better-class families than in poor families, who, for economic reasons, do not consume milk in any considerable quantities.

(4) It has been reported that the usual incubation period of the diseases carried by milk is somewhat shortened. This is probaby due to the heavy infection of the milk and the rapid absorption of the organisms.

(5) Most cases occur among heavy milk drinkers. Women and children are particularly susceptible, especially if the milk is taken raw. As many children are given heated milk only, this is not always the case.

(6) Milk-borne outbreaks tend to occur in medium-sized and smaller towns and in rural areas where the milk is unpasteurised, rather than in the large centres of population.

(7) When the infected milk supply is stopped or is pasteurised, the outbreak at once subsides.

Investigation of a Milk-borne Epidemic

The usual procedure in tracing milk-borne epidemics is to secure data from the persons affected or from their relatives, such data being collected and analysed in an attempt to locate the possible source or sources of infection. If all the affected persons have purchased milk from the same source, the milk will at once be suspect. The preparation of a *spot map* to indicate the cases as they are notified is very useful in this connection. This shows at a glance the incidence of cases along a route followed by a particular distributor. It is necessary to exercise particular care in securing data from sudden epidemics of disease, as a seemingly trivial happening may point to a definite source of infection. The work of tracing the cause of an epidemic, milk-borne or otherwise, is primarily one of elimination, in which one factor after another is excluded until the source of infection becomes obvious. If the data obtained points to the premises of a particular distributor, it may be found that one of the employees is suffering from the disease in question or is a " carrier " of such disease. If no such infected person can be connected with the distribution of the milk, inquiries must be made at the points of production, however many there may be, when itis probable that the source of infection will be traced. It is particularly necessary, in the case of bulked raw milk supplies, to investigate *all* points of production, as infection at one point will not be decreased in the bulked milk, but will render the whole highly infective. Pathogenic organisms introduced into the milk from human sources do not multiply to any extent, even under favourable conditions of temperature, so that laboratory investigation of the milk may be inconclusive.

Incidence of Milk-borne Infections

That milk is a potent factor in the spread of disease is widely recognised. In Great Britain alone since 1912 there have been nearly 100 outbreaks of milk-borne disease, affecting a large number of persons. Prior to 1912 there were many more. It is also estimated that in the last twenty years over 100,000 persons have contracted bovine tuberculosis in this country through milk infected with the causative organism. Jameson and Parkinson give the following summary of 612 milk-borne outbreaks of disease in the United States of America from 1908 to 1926 :

Disease.	No. of Outbreaks.	No. of Cases (incomplete).	No. of Deaths (incomplete).
Typhoid Fever	479	14,968	219
Paratyphoid	7	434	15
Diarrhœa and Dysentery . .	6	92	5
Septic Sore Throat . . .	42	21,045	139
Scarlet Fever	40	3,939	20
Diphtheria	26	971	7
Miscellaneous Diseases . .	12	878	5
Total . . .	612	42,327	410

The U.S.A. Public Health Report for the week ending April 3rd, 1931, mentions that there had been 258 milk-borne epidemics in the six years previous to the report, comprising the following diseases :

Disease.	No. of Epidemics.
Typhoid Fever	177
Scarlet Fever	34
Septic Sore Throat	22
Undulant Fever	8
Diphtheria	8
Miscellaneous	9
Total	258

Types of Infection

The diseases spread by the agency of milk fall into two groups :

(1) Those in which the infection is caused by the presence of the disease in the animal.

(2) Those in which the infection is due to an external agency, carried either in the water with which the dairy or farm is supplied, on the utensils used, or directly by the affected person.

(1) Diseases of Primary Origin in Dairy Cows

These comprise diseases affecting both man and animals, together with a few affecting animals only, and are :

(*a*) Tuberculosis.
(*b*) Contagious abortion.
(*c*) Foot and Mouth Disease.
(*d*) Anthrax.
(*e*) Actinomycosis and Botriomycosis.
(*f*) Mastitis.
(*g*) Cowpox.
(*h*) Digestive Affections.
(*i*) Miscellaneous.

(*a*) **Tuberculosis.** The *Mycobacterium tuberculosis* is the most common pathogenic organism present in milk and, in view of the disastrous results which have occurred and still are occurring through the consumption of milk so infected, the subject necessitates the most serious consideration. Following an exhaustive inquiry by a Special Committee of the People's League of Health, the following facts emerge regarding tuberculosis in the dairy herds of this country :

(1) At least 40 per cent. of the cows of this country are infected to a greater or lesser degree with tuberculosis.

(2) Approximately 0·2 per cent. of dairy cows are affected with tuberculosis of the udder, and are therefore yielding milk containing live tubercle organisms.

(3) Only some 3 per cent. of the cows affected are actually infective at any one time.

(4) The proportion of raw market milk containing living tubercle bacilli varies in different parts of the country from 2 to 13 per cent., with an average of 6·7 per cent.

(5) There is no evidence of any decrease in the incidence of this disease in cattle.

It must be remembered that the figure of 0·2 per cent. of cows with udders affected by this disease is an assumed figure, consisting of records obtained from various parts of the country, with the addition of an allowance for undetected cases, due to an absence of clinical signs. It is possible that a much higher percentage would be found if routine samples of milk were taken for biological examination from all milk-producing cattle. Particularly is this so when it is remembered that cows may excrete tubercle bacilli in the milk when the udder is unaffected. The milk may also become affected with particles of manure excreted by the infected animal or by means of its uterine discharges, which may splash into the milk during milking operations or may gain access viâ the milker's hands and clothing. Infected sputum from the animal may also gain access to the milk in the form of dried dust, and such sputum, when swallowed by the animal, will be excreted in the fæces. Milk will dissolve a large amount of fæcal matter without any apparent sign of pollution, and it is recorded that the organisms have been found in the fæces of apparently healthy animals. The large percentage of raw market milk infected with this organism is due to the prevalent bulking of the milk supplies. The milk from one affected cow will infect that from all the remaining healthy animals in the herd, or even milk from several other farms, provided the whole quantity is mixed together. It is sometimes stated that such bulking will dilute the infection. This, however, is fallacious, as has been proved by the biological examination of bulked milk when the infection has been traced back to one infected animal. This has occurred in many cases.

The bovine type of organism is chiefly responsible for non-pulmonary infections in man, the infection occurring almost exclusively in the alimentary tract, in which situation the predominant source of harm is milk consumed in its natural raw state. Naturally, the disease occurs chiefly in children up to five years of age, who are the largest consumers of milk. Above the age of sixteen years there is a progressive diminution in the incidence of the disease. The fact that there has been a marked fall in the non-pulmonary death-rate during the last few years is held by many members of the agricultural community to show that the disease, both in the human being and in animals, is rapidly becoming a negligible factor. There are five reasons for this decrease, none of which can be said to show that the incidence of disease generally among dairy cattle is any less than it was twenty years ago. These factors are :

(1) Increased interest in clean milk production with consequent healthier stock.

(2) Increased veterinary inspection, in which animals showing clinical signs are slaughtered.

(3) Increased sampling of milk for biological examinations, with the consequent removal and slaughter of affected animals under the Tuberculosis Orders, 1925 and 1938.

(4) Great increase in the quantity of milk which is either pasteurised or sterilised before sale. Such milk, if efficiently treated, is free from the organisms, as they are killed by the heating process although they may have been present in the milk before treatment.

(5) Increased activity by Child Welfare Centres. Many more babies are being fed on dried milk than was formerly the case. Further, many Child Welfare Authorities who supply fresh milk take precautions to ensure that such milk is above suspicion.

Dr. Stanley Griffiths reports that, in an unselected series of 1,068 cases of human tuberculosis investigated by him in this country, 20·7 per cent. were attributable to bovine infection. The figures he gives show an incidence of 37·55 per cent. of bovine disease in children under five years of age, with a progressive diminution to 6·25 per cent. from sixteen years of age upwards. Dr. Griffiths has also shown that a large proportion of the non-pulmonary cases which occur, especially in children, are caused by the bovine type of organism, and he gives the following figures :

	No. of Cases.	0–5 years.			5–15 years.			15 years and over.			% Bov. all ages.
		Hum.	Bov.	% Bov.	Hum.	Bov.	% Bov.	Hum.	Bov.	% Bov.	
Cervical Glands	116	3	18	85·7	28	26	48·1	32	9	27·9	45·7
Lupus	176	23	36	61·0	48	51	51·5	15	3	16·6	51·1
Scrofulodermia	54	7	6	46·1	17	10	37·0	13	1	7·1	31·5
Bone and Joint	511	60	24	28·6	277	65	19·0	81	4	4·7	18·2
Genito-urinary	23	—	—	—	2	1	33·3	17	3	15·0	17·4
Pulmonary	202	—	—	—	10	—	0·0	190	2	1·0	1·0
Tuberculous Meningitis	33	2	1	33·3	13	7	35·0	9	1	10·0	27·3
Autopsies	183	72	29	30·1	48	7	14·3	21	1	12·5	23·0
Miscellaneous	23	2	1	33·3	10	1	9·1	9	—	0·0	8·7
Total	1,321	169	115	68·04	453	168	37·08	397	24	6·2	22·47

The percentage of bovine infection in the 1,321 cases was 22·47. This compares favourably with the figures mentioned by the Royal Commission on Tuberculosis, which discovered that, of 60 cases investigated, 23 per cent. were of bovine type. In the Report of the People's League of Health previously mentioned, investigations revealed the following facts :

(1) Approximately 6 per cent. of all deaths from tuberculosis are caused by the bovine type of organism.

(2) Some 2,000 deaths occur annually from this cause, most of which are children.

(3) At least 4,000 fresh cases of bovine infection develop each year. The majority of these cases do not die, but the infection results in an immense amount of suffering, invalidity, and other permanent deformity, together with great expense to the country in the efforts made to effect a cure.

Wilson has stated that 6 per cent. of all deaths from tuberculosis are due to infection of bovine origin and this appears to be a reasonable assumption. If this is indeed true, and there is no reason to doubt it, 65,000 persons died of bovine tuberculosis between 1912 and 1937.

Various suggestions have been made for preventing this appalling incidence of the disease, among which may be mentioned :

(1) Efficient pasteurisation of all milk.
(2) Increased veterinary inspection of herds.
(3) More sampling of milk for biological examinations, with the removal of infected animals.
(4) The eradication of the disease in dairy herds.

All these methods have their supporters and, while the increased veterinary inspection of herds and sampling of milk for biological purposes would be useful, the aim should be to prevent any infection of the milk supply. This can only be achieved by the complete eradication of the disease in dairy cattle. While such measures were being taken, all milk supplies other than those from herds known to be free from the disease would require to be efficiently pasteurised. The Report of the People's League of Health makes the following recommendations for diminishing human tuberculosis of bovine origin :

(1) The aim should be to diminish and eliminate the disease from herds of cows, so that all milk should be free from infective organisms.

(2) Facilities for the elimination of infective cattle should be improved.

(3) The public should be protected at once by measures such as :

(*a*) More active aid and encouragement to producers to produce milk certified free from tubercle bacilli.

(*b*) An extension and enforcement of general hygienic measures in connection with milk.

(*c*) The larger Urban Authorities should be permitted to require all milk sold by retailers within their areas to be obtained from cows free from tuberculosis, or to be efficiently pasteurised, this scheme to be extended later to all districts.

(*d*) The effect of a compulsory system of pasteurisation should be studied as regards the nutritional value of the article and its influence upon the question of milk distribution.

Whatever measures are decided upon, they should be put into operation with the minimum of delay, in view of the serious results of infection by this disease.

(*b*) **Contagious abortion.** The presence of the *Brucella abortus* in the milk of cattle affected with contagious abortion and the cause of *brucellosis* has been recognised for over twenty years. The proportion of affected animals which secrete this organism in their milk has been variously estimated from as low as 20 per cent. to as high as 50 per cent., although it is probable that the incidence of the disease in dairy cattle is higher than in the case with tuberculosis. It may be true to say that 50 per cent. of the herds are infected with the causative organism, but this does not mean that 50 per cent. of animals are affected by the disease. Between 20 per cent. and 40 per cent. of raw milk samples have been found to contain the organism which is now recognised as the cause of undulant fever in man, bulked supplies being most heavily infected. Affected persons exhibit all the symptoms found in an attack of Malta fever, due to *Brucella melitensis* found in goat's milk, while there is a very close relationship between *Brucella abortus* and *Brucella melitensis.*

Since 1917, 219 cases are known to have occurred in this country, while during that period, there has been a steady, but slow, increase in the incidence of the disease. Since 1930, however, this increase has been more rapid. Wilson has stated that between 400 and 500 cases of undulant fever occur annually in this country, the majority being due to milk-borne infection.

In the United States of America the number of cases of this disease reported has risen from 1 in 1922 to 1,897 in 1935, and several epidemics have been reported in that country. It would appear that, as the possibility of human infection becomes better known, more and more cases are being recognised, errors of diagnosis in the past probably concealing such infections. When one considers the estimated number of animals affected with this disease, it appears that there must be considerable resistance on the part of most persons which prevents infection taking place, the disease developing only in persons whose resistance is low. On the other hand, the strain of the bacillus in certain cases may possess increased pathogenicity. The majority of infections occur in adults, and such infection results in long-continued fever, followed by a very protracted convalescence. The illness seldom terminates fatally, but may do so on occasion. The organisms gain entrance to the milk from the udder or by pollution of the milk after production by the infectious discharges from the animals.

The question of the incidence of undulant fever in man as a result of ingesting cow's milk is a matter for considerable further research.

(*c*) **Foot and Mouth Disease.** Cases of infection of human beings with this disease following the consumption of milk from infected cows have been reported in America, on the Continent, and also in this country. Milk from affected animals may give rise to severe gastro-intestinal disturbances, and the disease has been reported on the Continent in epidemic form. Children are apparently most susceptible, as, in an affected adult, the disease is usually mild in character. Occasionally, severe symptoms have been noted, and some cases have ended fatally. The most notable instance of an affected milk supply is that which caused an outbreak of the disease in Dover in February 1884. Two hundred and five persons in all were affected, the symptoms being local inflammation of the throat, enlargement of cervical glands, and in some cases vesicular eruptions. Four fatal cases occurred. The infection was traced to the milk supply from one distributor who obtained his milk from four farms. It was found that foot and mouth disease had broken out at one of the farms on the fourteenth day of the previous month, and that some of the milk from infected animals had been delivered to the distributor, who mixed it with his other milk prior to delivery. As confirmation of this it was found that the owner of the affected herd had sold milk and cream on two separate occasions to another retailer, among whose customers a further outbreak occurred. Cases have been reported from America, in Baltimore, and Kansas, but, with the present measures in force in this country for quarantine and the destruction of affected animals, this disease cannot be said to be a serious menace to the health of the milk-drinking community.

(*d*) **Anthrax.** Anthrax bacilli may be excreted in the milk of affected animals, such excretion occurring shortly before death. For this reason, the transmission of the disease to humans is unlikely, as milk secretion is considerably reduced when extreme fever, which is one of the characteristics of the later stages of the disease, commences. That the danger is, however, present is shown by a report by Savage of an outbreak of the disease among cattle in Chicago in June to August 1910, which placed the whole milk supply of the city in jeopardy. Twenty farms in all were involved, and 500 cows were exposed to the infection, 87 of which died. All farms on which affected cows were found were quarantined and the milk destroyed. As a result of the precautions taken, none of the suspected milk reached the city, although it is probable that, but for the speedy action of the City Authorities, infected milk might have been sold. Apart from the excretion of bacilli in the milk, there is also the possibility that the infected body discharges of one animal may soil the body of an unaffected neighbour, and may thus obtain entrance to the milk, which possibility must always be borne in mind. Hammer reports one case of anthrax in man from America which was caused by drinking milk from an infected source, but there is no evidence of similar cases having occurred in this country.

(*e*) **Actinomycosis and Botriomycosis.** The possibility of infection of human beings by the causative organisms of these diseases is certainly remote but not impossible. The organisms, if present in the milk, could only affect the human body by gaining entrance to some raw wound, such as a new tooth cavity, intestinal ulcer, or labial sore. No cases have been reported. When the disease is present in the udder, however, the milk frequently contains pus, and for this reason alone should not be used for human consumption.

(*f*) **Mastitis.** Mastitis is a common disease in dairy cattle, and is caused by a variety of streptococci and other organisms. The *Streptococcus agalacticæ* is the chief causative organism in the udders of cattle. This organism in itself is not pathogenic to man so far as is known. Such milk, however, cannot be considered suitable for human consumption owing to the large numbers of pus cells which it contains, while Brooks and Tidman have suggested that toxic substances may be present which may give rise to gastro-intestinal disturbances in susceptible human subjects. Some 40 per cent. to 50 per cent. of the dairy herds in the country are estimated to be affected with the disease in one form or another. Although such streptococci as are commonly present in this disease are not dangerous to the health of the consumers, *hæmolytic streptococci*, in every respect similar to those which produce human disease, have been found in the milk of cows affected with mastitis. There have been many outbreaks of septic throat, some occurring in the form of definite epidemics, and in many of these outbreaks proof has been forthcoming that the udders of some of the animals in the herds investigated were infected with streptococci similar to those responsible for the outbreaks. Streptococci of a scarlatinal type have also been isolated from cases of mastitis in herds.

In dealing with this disease, it is necessary to remember that, clinically, the types of mastitis which may be harmful to the consumer cannot be differentiated, bacteriological examination of the milk being therefore essential. As a general rule, it may be stated that the organisms from the udders affected with mastitis are non-pathogenic to man, but in view of the possible presence of pathogenic organisms, the milk from affected animals should not be used for human consumption.

Severe outbreaks of *septic throat* occurred in Massachusetts, U.S.A., in 1928, but the most notable outbreak in this country was that which occurred in Brighton, Hove, and Portslade in 1929–30. In this outbreak, over 1,000 families were affected, and 65 deaths occurred, the epidemic being limited to the customers of one dairy. Streptococci were found in the milk of one of the farms supplying the dairy. The milk supply from this farm was stopped, when the outbreak quickly abated. Inquiries at the farm showed that there had been several cases of illness among the workers. It was also discovered that there had been a considerable amount of mastitis among the animals.

Savage mentions an illuminating outbreak which occurred in Christiania in 1908. This was an extensive outbreak, in which every case began with a painful throat, swollen cervical glands and high temperatures being also general. Pyæmic complications were numerous, and a number of the persons affected died. The total number of notified cases was 548, but, as notification was not compulsory, this number was probably an understatement. The milk was supplied from one dairy, and the infection was finally traced to a cow with a diseased udder. The animal was slaughtered, an abscess being found in the udder. Bacteriological examination of pus from this abscess showed the presence of streptococci identical with those obtained from patients attacked by the epidemic. These streptococci were also pathogenic to mice. A further outbreak mentioned by Savage occurred in Colchester in 1905, when at least 600 cases were recorded. Swollen glands and tonsils, with pain in the throat, were the chief symptoms, but no deaths occurred. The milk supply in question was obtained by the distributor from six farms. At one of these farms a cow was found with similar symptoms, while there had also been cases of illness among the workers. The cessation of the outbreak was synchronous with the exclusion of the milk from this particular cow. Bacteriological examination of the milk showed that the septic throats were presumably due to streptococci, as the milk from one quarter of the affected animal showed an abundance of such organisms. Savage also mentions a eport by Jensen of an outbreak which occurred in Stockholm, where the nembers of nine families became ill with vomiting, diarrhœa, fever, weakness, nd cramp in the legs. The disease was traced to the use of milk from a herd omprising 14 cows, one of which was proved to be affected with mastitis. Two farm hands were ill with similar symptoms.

(*g*) **Cowpox.** This disease is due to an attenuated form of the virus of smallpox. In adults and children who have not been vaccinated, malaise and pyrexia follow the ingestion of such infected milk, while others protected by vaccination usually escape. In this country an outbreak limited to three persons occurred in the Chippenham Rural District in October 1925. The outbreak took place at a farm, three persons in all being affected. The farmer had been vaccinated in infancy and was not seriously attacked, but his son and daughter, who had not been vaccinated, showed the usual symptoms. It was found that several of the cows were suffering from cowpox. An interesting outbreak, which occurred at Leith from June to October 1904, is recorded by Savage. The outbreak consisted of diphtheria and also cases of septic throat. There were 19 notifications of diphtheria spread over the entire period, while there was apparently a close relationship between the diphtheria outbreak and the epidemic of septic throat. No cases of septic throat or suspected septic throat were found at the farms where the milk was produced. Several cows were, however, found to have ulcerated teats, which were diagnosed by a veterinary surgeon as cowpox. A dairymaid and the son of the farmer were affected with pustules on the hands. Swabs taken from the ulcers on the teats showed no Klebs-Loeffler bacilli, but occasionally organisms resembling these were detected, although such organisms were non-pathogenic to animals. This was definitely a case of throat infection due to cowpox, although apparently some of the cases showed all the clinical signs of diphtheria and were notified as such.

(*h*) **Digestive Affections.** Cases of food poisoning have been reported from the Continent following the consumption of milk, and have been attributed to the milk from cows suffering from intestinal disorders, the causative organisms being the *Bacillus enteritidis of Gaertner*, *Bacillus enteritidis* var. *dublin*, and *Bacterium typhi-murium*, which may have reached the milk supply by means of infected fæces. That this is possible is shown by an extensive outbreak of milk-borne enteritis due to *B. enteritidis* which occurred in Aberdeen in July 1925. Four hundred and ninety-seven cases were notified, with one death. A similar outbreak, in which 132 persons were affected, was reported from Wilton, Wiltshire during 1938. This was due to the *dublin* type of organism and most of the victims were children. In the Special Report Series, No. 92 (1925), of the Medical Research Council, Savage and Bruce White, in a study of 100 outbreaks of food poisoning, report that in 5 cases milk was the vehicle of infection. Cheese was responsible for 8 outbreaks and ice-cream for 1, and, as these are milk products, 14 cases in the hundred investigated can be said to have been due to infected milk. Human beings may be attacked with gastric enteritis of the *dublin* type, a fever resembling paratyphoid being caused.

(*i*) **Miscellaneous.** The importance of cuts and abrasions on the udder or teats should not be overlooked, as these may prove a suitable nidus for pathogenic organisms. Howard Jones mentions a case in which active *C. diphtheriæ* were cultivated from swabs taken from cowpox ulcers on the teats of two cows, the bacteria having lodged there from the hands of an infected milker. In 1902 and 1906 outbreaks of diphtheria, due to the presence of the causative organisms in ulcers on the teats of cows, were reported by Dean and Todd and by Ashby respectively, but apparently cattle are not subject to this disease, the organism being implanted upon the ulcers from the hands of an infected person. With regard to *scarlet fever*, it is apparently impossible to rule out the question of bovine scarlet fever while it is also possible that an animal may act as a carrier of this disease, as suggested by Savage in recording particulars of the Hendon outbreak of 1885. Milk supplied from a dairy in Hendon was the cause of outbreaks in several districts in London. It transpired that three newly-calved cows arrived at the Hendon farm from Derbyshire, and that this arrival shortly preceded the first notification of the disease. These three animals were kept in a separate shed, and the milk from the farm was distributed to Marylebone, Hampstead, and St. Pancras. It was found that the cows were suffering from some disease of the udder which spread to other cows in the herd. After being removed from the shed in which they were first installed, the three animals were moved from one shed to another, and this removal was followed by an outbreak of the disease in the district to which the supply of milk from these particular sheds was sent. The udders and teats of the animals showed eruptions which were communicable from cow to cow. Sub-cultures of the discharges from these ulcers were inoculated into calves, and produced a disease which had affinities, under some conditions, with the disease in the milking cows and, in others, with scarlet fever in human beings. The scarlet fever appeared in all but one of the five localities to which the milk was distributed. The one exception did not receive any milk from the affected animals until later. When some of the milk from the affected cows was sent to this district, the disease appeared there. The sale of milk from this farm was prohibited in the London Boroughs, and during this prohibition some of it was given away to poor people in Hendon, following which an outbreak of the disease occurred in six families supplied in this way. This latter outbreak occurred after the disease had subsided in London. An outbreak of scarlet fever was also recorded in the Borough of Bedford in October 1926. Seventy-two cases occurred, of which 61 were in houses supplied with milk from one dealer. When the milk supply was stopped, the disease abated. There was no suspicion of scarlet fever among the milkers or their families or among any of the other persons on the farm. Although this outbreak is held in many quarters to be due to scarlet fever of the animals, it is possible, as in other cases, that it was due to untraced human infection.

(2) Diseases Peculiar to Man

By far the larger number of outbreaks of disease due to infected milk are those in which infection has had its origin in cases of specific disease in the human being. The diseases spread in this way are :

(*a*) Typhoid Fever.
(*b*) Paratyphoid Fever.
(*c*) Dysentery.
(*d*) Diphtheria.
(*e*) Scarlet Fever.
(*f*) Cholera.
(*g*) Human Tuberculosis.
(*h*) Epidemic or Summer Diarrhœa.
(*i*) Food Poisoning.

(*a*) **Typhoid Fever.** This is one of the principal infectious diseases of human origin which can be transmitted by milk-borne epidemics. The sources of outbreaks of this disease are :

(1) Persons suffering from the disease.
(2) "Carriers."
(3) Persons carrying the organisms on their hands or clothing after having been in contact with an infected person or a "carrier."

The fæces and urine of both patients and "carriers" are the chief sources of typhoid bacilli, the milk being contaminated by the uncleanly habits of such persons during handling. Some 3 to 4 per cent. of typhoid patients become "carriers" for some period after their recovery ; in some instances, this state may continue for years. Fly infection of the milk is also possible, the bacilli being conveyed by these insects from privies and middens where the fæces and urine of infected persons may be deposited. Flies may also contaminate the milk utensils after sterilisation. Dogs and cats can also infect utensils if they are allowed to come into contact with such articles after having themselves been in contact with a person suffering from the disease. Surface washings may carry pollution into ponds and other water supplies used for dairy purposes, and such supplies may also be polluted by faulty drainage systems. In every epidemic of this disease believed to be caused by an infected milk supply, if no positive case of the disease can be found, the possibility of a "carrier" should be borne in mind, and steps taken accordingly. If investigation on these lines is a failure, the general sanitation of the farm premises should be surveyed, particular attention being paid to the water supply, which may be polluted. Bacteriological examination of the water supply is always advisable, while medical examination of all persons handling the milk, together with the appropriate blood tests, should be carried out.

There have been innumerable outbreaks of this disease due to infected milk, and it is only necessary to mention a few of the more recent of these. In August 1932 an outbreak in which 45 cases were notified of whom 4 died was reported from the urban districts of Blaydon and Ryton. There were also 7 associated cases in the adjoining district of Newcastle-upon-Tyne. The cause was traced to raw milk produced in Blaydon, which was infected at the farm. The outbreak ceased when the cattle were moved elsewhere and the milking staff changed. At Polperro, in the months of July to September 1929, 15 cases of this disease were reported. The milk was found to be infected through the washing of the utensils in polluted water which contained organisms of intestinal origin. An outbreak occurred at Penzance in August and September 1923, in which 22 cases were notified, 1 proving fatal. The infection was traced to a farm in an adjoining district, where three unrecognised cases of the disease had occurred. When the milk supply was stopped, the outbreak subsided. The most serious outbreak in recent years occurred in Montreal in 1927. From March 1st to July 16th of that year 5,014 cases occurred, with 488 deaths. Two peaks occurred, one in the middle of March and the other in the middle of May. As a large number of those affected used milk from one particular dairy, this supply at once came under suspicion. The milk arrived at this dairy from a large number of farms, varying between 1,200 and 1,500. Some came through four receiving stations, one of which used water for washing purposes from a polluted river. The milk was pasteurised on arrival in the city, but this treatment was unsatisfactory, as, although the plant was efficient, it was not properly used. The foreman in charge of the plant was found to be a "carrier," and was suspended from duty on April 16th. He could not, therefore, under any circumstances be held responsible for the second outbreak, the peak of which occurred in May. As more milk was received at the plant on certain occasions than was run through, it is possible that, upon occasion, a proportion of such milk was delivered untreated after it had been polluted by the impure water supply used for washing purposes at one of the four collecting stations.

The epidemic in Bournemouth and district which occurred in 1936 is still fresh in the memory, being a reminder of the results which the consumption of raw, infected milk can produce. In this epidemic, 718 persons were affected, of whom 400 were visitors to the town. Fifty-one of the residents died, as did several of the visitors who had contracted the disease. All the primary cases had consumed raw milk from one dairy which had obtained its supplies from a number of farms.

(*b*) **Paratyphoid Fever.** Although outbreaks of this disease are not so common as typhoid epidemics due to infected milk, they do occur, and infected persons, " carriers," fæces, and urine are the chief sources of the responsible organisms. The sources and causes of contamination are similar to those mentioned in the case of typhoid fever, and investigation of outbreaks of this disease should be carried out along similar lines. One of the largest outbreaks of recent years in this country was that which affected the Epping Urban and Rural Districts, the Urban Districts of Chingford and Loughton, and the Boroughs of Ilford and Walthamstow in February and March 1930. In all, 307 cases were notified, of which 233 were in the Urban District of Epping. The cause of the infection was found to be an infected milker. When this person was detected and ceased handling the milk, and when the premises were disinfected, the outbreak subsided. A small outbreak following this occurred in the Epping Urban and Rural Districts in September and October 1933. There were 19 cases in the Urban District and 3 in the Rural Area. No suspicion attached to any person handling the milk, and the supposition is that the cows had carried the infection on their coats and udders from land polluted by sewage upon which they grazed. It appears that organisms of this disease and of typhoid fever had been found in the sewage of the district from time to time since the previous outbreak in 1930. The suspected supply was pasteurised and the outbreak subsided. In October and November 1927 an outbreak of milk-borne paratyphoid fever occurred in the Borough and the Rural District of Hemel Hempstead and the Rural District of Watford. The disease was not at first recognised, being mistaken for influenza. One hundred and sixty-six cases occurred, the incidence being greatest in persons under twenty-one years of age. There were no deaths. The infection was traced to human agency infecting the supply at the farm from which the distributor supplying the affected persons obtained his milk. Five roundsmen were also found to be affected, but no evidence of any infection of the supply by them was traced. In the Borough and Rural District of Newark and the Rural District of Southwell, 39 cases were notified in June and July 1927. Thirty cases were traced to the consumption of milk from one retailer. Human infection of the milk at the farm supplying the retailer was found to be the cause of the outbreak. The outbreak subsided when the farm-hands were prevented from handling the milk. In August and September 1927, 48 cases of this disease occurred in the Borough of Tenterden, with 5 cases occurring outside the Borough. The milk supply of each case with one exception was obtained from a local dairy. Human infection at one of the farms supplying milk to the dairy was found to be the cause. When the milk supply was stopped, the outbreak subsided. An outbreak occurred in the Borough and Rural District of Chorley in 1924, in which 57 cases were notified, 2 of which proved fatal. A case of paratyphoid fever had occurred in a farm in the rural district, the milk from which was distributed within the borough. The patient was permitted to remain at home, the result being that four of the farmer's household became infected, with a consequent infection of the milk after production.

(*c*) **Dysentery.** The sources of this disease are similar to those of typhoid and paratyphoid fever, and the investigation of any outbreak suspected to be milk-borne should be similarly carried out. Records show that up to the end of 1926, six epidemics of this disease had occurred in the United States of America. An outbreak occurred in Massachusetts, in 1916, in which 20 cases were notified. Ninety per cent. of the cases were children, who were all consumers of milk from one farm. The conditions at this farm were good, but at another farm where the cans were washed, conditions were unsatisfactory. Cases of illness occurred at this latter farm before the onset of the other cases, and involved the father and other members of the household. The father continued to milk during the entire course of his illness. An outbreak of 18 cases of this disease occurred at Lynton in 1922. Infection was spread through the agency of milk, and the source of the infection was found to be a dairy foreman who had suffered from an attack of the disease in 1918, and who was found to be an active " carrier." The foreman was prohibited from taking any further part in dairy work or in the handling of milk, when the outbreak subsided. Dr. Bruce White, who investigated the outbreak on behalf of the Ministry of Health, points out two very interesting facts :

(1) That milk is an unusual medium for the dispersal of *B. dysenteriæ.*

(2) That the period during which the farm foreman had been a " carrier " of *B. dysenteriæ* was of unusual length.

In 1937 an outbreak due to milk-borne infection occurred at St. Andrews, affecting 300 persons, while in 1938 a similar outbreak affecting 70 persons occurred at Bedford.

(*d*) **Diphtheria.** Epidemics of milk-borne diphtheria have been of frequent occurrence, the disease usually originating from infected persons or " carriers." Dogs and cats, which are immune from the disease, may act as " carriers," infecting the milk or utensils. The secretions from the mouth, nose or throat may be sources of infection, and, as " droplet " infection is common in this disease, contamination is rendered easy when the milk is handled by persons harbouring the causative organisms. Infected milkers may contaminate the milk by coughing, sneezing, or by expectorating on the hands during milking operations. Infected air in a room where the milk is stored in open cans and churns may also result in contamination. Such infection of the air is caused by the expirations of an infected person working in the room. The hands of the infected person may contaminate the milk in handling either it or the utensils. In carrying out investigations, infected persons or " carriers " must be discovered. The possibility of secondary infection of any sores on the cow's teats should also be borne in mind. A diphtheria outbreak occurred in 1919 at Williamstown, Massachusetts, resulting in 32 cases. The manner in which the milk supply was infected was unusual. The daughter of the owner of the farm from which the milk came had a septic finger, and cultures taken from the sore showed the presence of the *Corynebacterium diphtheriæ.* The girl had been milking and helping in the dairy. There was a second outbreak responsible for

14 cases, and one of the cows at this farm was found to have a teat affected with the organism, while the owner of the farm had similar organisms in a sore on his hand.

During the period 1907–36, 5 outbreaks of milk-borne diphtheria were recorded in Glasgow. The frequency of diphtheretic infection of milk is, however, less than that of scarlet fever.

(*e*) **Scarlet Fever.** The organisms associated with this disease gain access to milk from persons suffering from scarlet fever or from contacts with infected persons. " Carriers," in the accepted sense of the term, are not easily detected although they undoubtedly exist, while the organisms are capable of existing in a virulent form for some considerable time, apart from the infected person. In tracking the primary origin of milk-borne epidemics of this disease, detection of case-contacts and their segregation will usually put an end to any outbreak. " Carriers " of *hæmolytic streptococci* should also be sought out and prohibited from handling the milk. An outbreak of this disease occurred in Northampton in November 1926. In all, 103 cases were notified, 82 of which obtained their milk from a certain farm. There were also 13 cases in adjoining districts, in families obtaining milk from the same farm. The milk from this farm was treated in two ways. Half was pasteurised and the consumers of this portion were not affected, the cases occurring among the consumers of the other portion of the supply which was sold raw. The probable infective agent was a milker, who had, previous to outbreak, been ill with what was said to be influenza. When he returned to work, the outbreak commenced. The milker in question was given other work away from the milk supply and the raw milk was pasteurised, when the outbreak subsided. Another outbreak occurred in Lewes in November 1928, involving 26 persons. The origin was traced to a farm, but no persons resident there were found to be either suffering from the disease or to have had it. Two children of a cowman who lived at some distance from the premises had contracted scarlet fever two months previous to the outbreak. It is thought that the infection was carried on the cowman's clothing, upon which the organism had remained virulent during the interval. In Stoke-on-Trent an outbreak of scarlet fever due to milk was reported in 1923, 281 cases being notified in eight weeks. The milk was infected by human agency at a farm supplying a wholesale dairy. When this supply was stopped, the outbreak subsided. In January 1933 an interesting outbreak of scarlet fever occurred in Hyde, in which 43 cases were notified. Four deaths occurred. The outbreak was traced to the milk supply, and the source of infection was found to be a person handling the milk. This man was undergoing treatment by his own doctor for " sore throat," and *hæmolytic streptococci* were grown from his throat swabs. He was suspended from duty, following which the outbreak abated. No infection of the supply was traced to the animals in the herd although they were carefully examined. In 47 per cent. of the households affected, other cases of septic throat occurred during the progress of the scarlet fever outbreak. In this connection two questions arise :

(1) Does the passage of streptococci through milk increase its virulence ?

(2) Do streptococci grow more freely in milk, so that those consuming such an infected product obtain a larger dosage than would otherwise occur in the case of droplet infection ?

It is probable that the answer to both these questions is in the affirmative.

An outbreak occurred in the early months of 1935 at Denham in the area of the Eton Rural District Council, among children attending council schools, which was traced to milk infected by " carriers " of *hæmolytic streptococci* (*type* 1). One hundred children were directly infected by raw milk from two local farms with two deaths. The children who escaped had either dried malted milk or did not have any milk at school. A milker at the farm was found to have *type* 1 *streptococci* in his throat, and this man, together with his two children who were similarly affected, were removed to hospital. The milk supply was stopped and the epidemic ceased.

In the same year an outbreak affecting 487 persons of whom 6 died, occurred in Chelmsford and district, while in 1936 there was an outbreak at Doncaster in which 186 cases of scarlet fever and 229 cases of " sore throat " were notified. The causative organism was *Streptococcus pyogenes* (*type* 2). Three deaths occurred. In every case raw milk was proved to be the vehicle of infection.

In 1938, an outbreak occurred at Romford in which 18 cases were infected. The farmer and one of his employees had sore throats and had been milking. Again the causative organism was *Streptococcus pyogenes* (*type* 2).

(*f*) **Cholera.** This disease may be transmitted by raw milk. The fæces of infected persons are the chief source of the organisms, and dirty habits and bad sanitation will facilitate their access to the milk. Such outbreaks are rare as the organisms die rapidly in milk, while in addition this disease is not common in this country. Acute epidemics, however, occurred in two hospitals in the Near East during the Great War. British troops were affected, there being 35 cases in one hospital with 14 deaths, and in the other, 19 cases with 10 deaths. The milk was usually sterilised, but it occasionally arrived late when sterilisation was not supervised.

(*g*) **Human Tuberculosis.** Cases of milk affected with the bacillus of human tuberculosis have not as yet been reported, but, as milk may be infected by persons suffering from phthisis who handle either the milk or the utensils, the possibility should always be borne in mind.

(*h*) **Epidemic or Summer Diarrhœa.** This is primarily a disease of the late summer months. As high bacterial counts in milk are commoner at this period of the year, this is sometimes assumed to be the cause. There does not appear to be any specific organism responsible for such outbreaks, and probably a number of organisms are involved, while the products of bacterial growth may also be a factor. The disease may be conveyed by milk improperly handled or stored, infection usually entering by way of dust and flies. Proper storage of the milk and, if necessary, the boiling of same in the home are essential. There can be little doubt that the major degree of contamination occurs in the home. The disease is more prevalent among bottle-fed than among breast-fed children, and is certainly more widespread in districts where the scavenging arrangements are poor and conservancy systems are in use. During 1914 there were 17·37 deaths from this disease per 1,000 births in England and Wales. In 1933 the figure had fallen to 6·13. A marked decline occurs after the age of one year. The disease is more prevalent in the large centres of population than it is in the rural and semi-rural areas.

(*i*) **Food Poisoning.** All the causative organisms of food poisoning affecting man may gain access to milk in a similar manner to other disease-producing bacteria. " Carriers " are most uncommon and the infection of utensils is usually due to contamination by persons suffering from a mild attack or from infected fæces of animals or rats, as mentioned below. The organisms multiply readily in milk at ordinary temperatures.

Finally, the methods of infection by rats or from water supplies require to be considered.

(*a*) **Infection by Rats.** Rats suffer from a form of typhoid caused by *Bacillus enteritidis* or *Bact. typhi-murium.* This rodent typhoid is infective both to human beings and to cattle, many rats becoming either temporary or permanent "carriers," infecting milk, water supplies or utensils. Two outbreaks of milk-borne disease caused by *Streptococcus moniliformis* have been recorded. This organism is frequently present in the nasal organs of rats and the cause of these two outbreaks was thought to be due to rat infection of the milk.

(*b*) **Infection from Water Supplies.** It has already been mentioned that water used for washing utensils and the udders of cattle may have been the cause of milk-borne outbreaks of typhoid, paratyphoid or dysentery when polluted by human fæces. In addition, food poisoning organisms from such sources or from rats may pollute the water supply. River water is most often contaminated, although troubles may arise from the employment of shallow well or surface supplies for dairy purposes if such are used without proper purification. Water infected with *Bacillus enteritidis* or with organisms of the *dublin* type may, if used for drinking purposes, cause the animals to suffer from intestinal infections and the causative organisms may obtain entrance to the milk from the fæces. Shaw has suggested in connection with the Bournemouth outbreak that cows may become infected with typhoid bacilli, but this has not been proved.

TAINTS IN MILK

Milk, in common with many other food-stuffs, is liable to assimilate a variety of taints and odours, due in many cases to bad management and improper storage. Such defective flavours, which are by no means conducive to good health, may arise from any one of the following causes :

(1) Physiological effects.
(2) Some ailment or disease of the animal.
(3) The food supply of the animal.
(4) Bacterial infection of the milk following withdrawal from the udder.
(5) The effects of oxidation during treatment and storage.
(6) Processing of milk, i.e. homogenisation or sterilisation.
(7) The absorption of taints from strong-smelling articles stored in close proximity to the milk.

It is very rare for food-stuffs to produce a direct detrimental effect upon the taste or smell of milk, although in some cases this may be possible. Almost all the smells and taints traceable to the food have been acquired by the milk standing in a highly tainted *atmosphere* smelling strongly of dung or of highly odoriferous food-stuffs which have been left lying in the vicinity.

One of the principal taints due to physiological change in the animal is the strong bitter taste sometimes found in milk from *cows which have been a long period in milk.* This taint is due to a physiological change in the milk and, when such milk can be traced to an individual cow, that animal should be immediately dried off. When the cow comes into milk again it will in all probability be found to be perfectly normal. A rancid taint may be due to the same cause. Another taint due to physiological effects, and one which is rather more objectionable, is that found in the milk of certain animals which have *aborted*, especially when the after birth has been retained. This taint or smell is recognisable up to a period of three months after abortion has occurred, but it should be stated that the milk from all cases of abortion does not exhibit this taint. An objectionable taste may also be due to a cow *cleansing badly after calving*.

Probably the principal *bacterial* cause of taint is one which produces a peculiar toasted taste or smell in the milk. This develops some fifteen hours after milking has taken place, and is caused by *mastitis* of so mild a character as to have gone unobserved by the milkers. This disorder of the udder, however, is generally recognisable by clots in the foremilk, and the milk from cows so affected should be eliminated from the remainder of the supply. This disorder is temporary.

Milk may also be affected with gaseous fermentations due to *yeasts* such as *Torula cremoris* and *bacteria* such as *B. coli communis*.

Ropiness or *sliminess*, although perhaps not properly coming under the heading of taint, should be considered with it. This may be due to catarrh of the udder of the cow, unsuitable brewers' grains used in feeding, impure drinking water, or faulty sterilisation of the utensils. The eating of butterwort by the cow is also stated to be a cause of this defect. If milk is stored in a warm situation, in a damp milkroom or near stagnant water, it often exhibits this phenomenon. The washing of churns and other utensils in water affected with the causative organisms is another source of infection. In some districts, badly drained or low-lying marshland is traversed by cattle, and under such conditions their udders and quarters may be splashed with moisture laden with the causative organisms. If care is not taken, such organisms are certain to find their way into the milk pail. The principal organisms causing ropiness of milk are *B. lactis viscosus* and *Bacillus aerogenes*, although *staphylococci* and some organisms of the caliform group may also be the cause. Sliminess is caused by several different bacteria, chief among which is the *Streptococcus hollandicus*. These organisms have been isolated from milk, whey, food substances, straw, the air of the cowshed, and from spring water, showing how widespread is their distribution. If milk is slimy, all the milk from each cow in the herd should be carefully examined until the animal affecting the supply is discovered.

It is not uncommon to see milk which is coloured *blue, yellow, or red*. This is generally found to be brought about by bacterial action. Blue coloration of the milk is generally caused by the action of *B. violosis* or *B. cyanogenes ;* yellow by *B. synscantha ;* and red, if bacterial in origin, by either *B. prodigiosus* or *Torula glutinis*. If the red coloration is due to bacterial action, the milk, when it has been allowed to settle, will show the distinctive colour on the surface. If the cause is red water or the breakdown of a blood-vessel in the udder, the upper layers of the milk will be normal, the colour only appearing in the lower portion. Pastures rich in clover are said to favour the appearance of *B. cyanogenes*, which has also been found in hay dust and ditch water.

Soapiness of the milk is caused by *Lactis saponacis*, which originates in the food and straw. Soapy milk, if shaken, gives a fine, vesicular, tenacious foam. A *fishy* taste may be due to pasturing the animals on meadows which have recently been flooded. *Watery* milk may be caused by feeding on too wet pastures or frozen root crops.

If good wholesome food is given to the animals, there should be no tainting of the milk from this cause, but taints may be introduced by excessive feeding of turnips, fish meal, cider pulp, tomato and rape-seed cakes, mouldy cakes and meals, beet pulp and tops, and by garlic and camomile weeds found in the fodder. *Bitter* milk may be due to food-stuffs, such as vetches, lupins, or wormwood, while a large number of common field plants may also be the cause. Food-stuffs in good condition should always be supplied, and restricted amounts of the foods liable to taint milk should be given. If the taint is caused by unsatisfactory feeding, it will make its first appearance in the milk 12 to 36 hours after such food has been consumed by the animal. The taint will persist for a similar period after the particular food-stuff has been withheld. If the taint is of bacterial origin, the bitterness will develop in the milk after it has been allowed to stand for some time.

As the whole of a milk supply may become tainted owing to the abnormalities in the supply from one cow, every effort should be made to locate the animal or animals causing the mischief. It will often be found that this can only be done by testing the milk of each cow separately. When the animal has been discovered, it should always be milked last and the milk destroyed as a prevention against spread of the infection. The utensils used for milking such animals require careful washing and sterilisation.

The exposure of milk to sunlight sometimes causes it to have a *tallowy* flavour, while, if uncooled milk is placed in closed vessels, a *putrid* odour may be observed.

Oiliness and a variety of *metallic taints* may be found in milk, and are due to defects in the utensils which come into contact with it after production. Although it must be stated that the milk from some animals will develop the taint spontaneously while the exposure of milk to strong sunlight or excessive irradiation may cause an oily flavour. Oiliness generally develops due to a reaction of the milk with the exposed copper and is due to the oxidation of the butter-fat. Such action takes place when milk passes over a cooler upon whose surface copper is exposed following wearing of the tin. This action on the milk is more prevalent in winter than in summer, due to the fact that there are few bacteria growing to use up the oxygen which is necessary for the reaction. Metallic taints can be avoided if tinned steel, glass-lined, or " Staybrite " metal equipment only is used. Other metals, such as brass, nickel or bronze, tend to taint the milk.

The *homogenisation* of milk to break up the fat globules tends to give the article a slight oily taint, while the burning of the lactose or milk sugar in the *sterilisation* process due to the high temperature to which the milk is heated gives the milk a peculiar burnt flavour. This change is known as " caramelisation." The exposure of a thin film of milk to *ultra-violet rays*, as happens in the irradiation of milk for too long a period, will also taint the milk.

If milk is stored uncovered in shops or in the home near *fish*, *paraffin*, or other strong-smelling substances for any length of time, it will absorb such smells to a variable extent, and may become offensive to the palate. The practice of selling milk in general shops stored in large uncovered bowls on the counter should not be allowed. General shops usually sell firelighters which contain a large amount of paraffin, and this also is liable to taint the milk. Milk should always be kept covered to prevent any opportunity of this occurring either in the shop or in the home.

If any taint in milk is discovered the first step is to decide whether it is due to bacterial or non-bacterial action. This may be proved by inoculating a small portion of the tainted product into clean, wholesome milk which is stored in a warm place and noting if the taint is reproduced. If it is not, it is probable that the cause of the trouble is non-bacterial and all methods of treatment, equipment, and metal surfaces should be examined in addition to conditions existing generally at the point of production, together with feeding stuffs and pastures. If the taint is proved to be bacterial in origin, all suspected sources should be carefully examined. In case of difficulty the services of the Provincial Dairy bacteriologist should be called in, and he, with the advantages afforded by laboratory equipment, will be able to trace the source of the taint with little trouble.

Stoppage of Infected Supplies

Legal powers are provided by Section 25 of the Food and Drugs Act, 1938, for prohibiting the sale of tuberculous milk or of milk from a cow suffering from tuberculosis of the udder, tuberculous emaciation and from other diseases specified in Part 1 of the First Schedule of that Act. (See pages 431 and 432). Persons who are aware that they are suffering from tuberculosis of the respiratory tract must not be employed in the handling of milk or milk vessels. The Public Health (Prevention of Tuberculosis) Regulations, 1925, permit a local authority to stop an affected person working at his occupation, suitable compensation being usually paid. The Tuberculosis Order of 1938 enables an authority under the Diseases of Animals Acts to follow up detection of bovine animals suffering from tuberculosis by slaughter, and also to pay compensation graded according to the degree of the disease.

The Medical Officer of Health is given powers in the Milk and Dairies Order, 1926, to exclude all persons suffering from infectious disease or contacts of same from handling milk, and he may also stop a supply of milk for twenty-four hours if he is satisfied that a person is suffering from an infectious disease conveyed by the milk in question. Under the Public Health (Infectious Disease) Regulations, 1927, any person suffering from typhoid fever, paratyphoid fever or dysentery, or a " carrier " of such diseases, may be excluded from any occupation connected with the preparation and handling of food and drink.

(*For further details regarding legislation, see Chapter XI.*)

CHAPTER III

THE COW

In considering the production of milk it should never be forgotten that the cow is the original source of our milk supply, and that milk cannot be produced by any amount of legislation, however efficient that legislation may be. Knowledge concerning the care of the animal and some understanding of its needs are therefore essential.

Historical and General

The principal types of the present-day breeds of cattle have only been evolved by a slow and gradual process which has taken many years to complete. The existing breeds, while satisfactory, cannot be considered to be final, as breeders are continually making efforts to improve stock. The Aurochs, which became extinct in the fifteenth century, was undoubtedly the ancestor of our present cattle, although this animal varied in many respects from the type with which we are now familiar. Those animals roamed the forests with which Europe and our own country were covered, obtaining their food from the undergrowth and in the thickets. As the forests were destroyed, the animals gradually became extinct, except on the preserved estates where they lingered until the beginning of the seventeenth century. The Aurochs was a huge animal, much larger than any of our present-day breeds of dairy cattle, a fact which has been conclusively proved by the size of the skeletons and heads discovered in various parts of Great Britain and the Continent. The span of the horns alone was at least 50 inches from tip to tip. The nearest comparison to the Aurochs is to be found in the Park cattle and in the Welsh breed. The Park breeds of cattle are descended from the early domesticated types of cattle, and, when the parklands were enclosed in the thirteenth century, these half-wild animals were separated from the rest of the cattle in the country, with the result that the breed remained pure and true to type, particularly in the case of the Chillingham herd. This type of cattle generally has white curly hair although black markings are sometimes found, and such animals often produce black calves. White is the prevailing colour of wild cattle, and it is interesting to note that cattle escaping from domestication and becoming wild return in subsequent generations to this colour.

Cattle have been domesticated from very early times. The monks and large landholders were the first to undertake the careful selection of cattle for breeding purposes, their aim being to provide animals which could not only help in the farm work and act as beasts of burden, but would also be useful as a source of sustenance after slaughter. Owing to the lack of sufficient food during the winter months, many animals were thus killed and their flesh salted. Their value as milk producers was not realised until a much later date, when, owing to the increased appreciation of this article, serious endeavour was made to evolve an animal which would yield a profitable supply of milk.

Climate and surroundings influence the various types of animals found, while good food under peaceful conditions causes increase in their size. In cold climates the size of the cattle is considerably reduced, while their skin and hair are thick. The damper the climate, the more noticeable do these phenomena become. Cattle were, as in the case of the Aurochs, originally forest animals, browsing on the grass, herbage, and young shoots in the clearings of the forest, and retiring into the denser parts to chew their cud under peaceful conditions. They do not, as a rule, thrive in tropical or mountainous country, but progress well on grasslands and in undulating districts such as are to be found in Great Britain.

Domesticated cattle mature much more quickly than do wild animals, this being apparent to-day when the various breeds are considered. Shorthorns mature much earlier than do the Welsh or Highland cattle, this being particularly noticeable in the teeth of such animals. The present types of dairy cattle are the result of careful artificial selection, and, following a process of in-breeding, these types have been fixed. Cattle have been bred by man, and such breeding has, in many cases, only been obtained at the expense of the stamina and constitution of the animal. The middle of the eighteenth century saw the commencement of scientific cattle breeding, and the assistance of science, together with acquired experience, has made this country pre-eminent in the quality of its dairy cattle, although the natural advantages of soil, climate, pasturage, and stock were initially present.

Bovines may be divided into three dissimilar types, as follows :

(1) Those animals notable for their milking qualities only.
(2) Those which put on flesh with ease and supply excellent meat.
(3) Those which supply excellent meat and are good milkers.

The science of milk production has carried matters even further, the special qualities of milk from the different breeds having now been determined. Although the present methods used in the breeding of dairy cattle have produced good animals, such methods leave considerable room for improvement. The usual procedure is either to sell off or fatten calves for the butcher, and to buy ready-made milking cows without paying the necessary attention to the ancestry of the purchased animal. When such animals become dry, they in turn are sent off to market, and fresh cows, either in calf or newly calved, are purchased. Herein lies the mistake. It would be more profitable if all producers, when they had found a cow which gave a good yield of milk of reasonable quality, were to keep such an animal in the herd and use it as a reproducer of further quality animals.

Breeds of Cattle

Generally speaking, the majority of cows in this country are crossbreds and retain very little of the original strain of their ancestors. There are, however, certain pure breeds kept for milking purposes, and these are :

(1) Shorthorn.
(2) Lincoln Red Shorthorn.
(3) Red Poll.
(4) Jersey and Guernsey.
(5) Kerry and Dexter Kerry.
(6) Ayrshire.
(7) Welsh Black.
(8) Friesian.
(9) South Devon.
(10) Hereford.

The tables set out below show the position of these breeds as regards yield of milk and the fat content of their product.

Yield of Milk.	*Butter-fat Percentage.*
(1) Friesian.	(1) Jersey and Guernsey.
(2) Lincoln Red.	(2) Kerry and Dexter Kerry.
(3) Dairy Shorthorn	(3) Welsh Black.
(4) South Devon.	(4) South Devon.
(5) Ayrshire.	(5) Ayrshire.
(6) Welsh Black.	(6) Red Poll.
(7) Red Poll.	(7) Dairy Shorthorn.
(8) Guernsey and Jersey.	(8) Lincoln Red.
(9) Hereford.	(9) Hereford.
(10) Kerry and Dexter Kerry.	(10) Friesian.

It will be seen that the Dairy Shorthorn, probably the most popular animal to-day, is a very useful type, giving a good yield of milk with a fairly good fat percentage. In addition, it will also be noticed that a high yield and a low fat percentage generally, though not invariably, coincide.

As already indicated, the crossbred animal forms the largest proportion of the dairy herds of this country. The crossing of two pure-bred animals produces the best results, but many of our dairy cattle are the result of crossing two crossbreds, too often with unsatisfactory results. The constitution and yield of the animals can often be improved by proper mating, this being particularly the case if the parents possess good dairying qualities or are descendants of good dairy cattle. A good Shorthorn bull crossed with a Guernsey or an Ayrshire cow will result in good milking animals, and in this connection it must be remembered that the milking strain in the bull, and its freedom from disease, is quite as important as that in the cow. Good healthy parents possessed of the necessary dairying qualities should always be used for breeding purposes, and, if this is done, satisfactory stock will ensue.

The qualities of the various pure breeds kept for dairy purposes may be summarised as follows (the live weights are given approximately for adult animals and the milk yields are also approximate at a period of nine weeks after calving) :

(1) The Shorthorn

This is the most important English breed, and is to be found in all parts of the country. The ancestry of this breed is not very clear, but it is certain that it originated in Durham and North Yorkshire. The breed has spread throughout the world, so high are its qualities rated among both meat and milk producers, and bulls for stud purposes are continually being exported. The early type of this breed was larger in size than the present-day animal, which has been developed along dual-purpose lines, so that the carcase makes good beef when the animals' milking days are over. Further specialisation has brought about the development of two different types of animal, i.e. Beef and Dairy Shorthorns. This breed is most prevalent in the North and Midlands, as apparently the more invigorating qualities of the air in those districts are more suited to its constitution. Dairy Shorthorns have a milk yield of 50 lb. per day and the live weight is 1,365 lb. The commonest colours are red or deep roan, although red and white types are also to be found. For some reason a pure white Shorthorn is unpopular. The animal has a long small head, while the neck is thin towards the head, rapidly thickening as it approaches the shoulder. The horns should be short, blunt, and creamy. They should not have black tips, and should curve with age inwards or upwards. The girth should be deep, with wide ribs, while the body is usually longish and covered with fine hair. The udder is well forward and has large teats.

(2) Lincoln Red Shorthorn

This breed is peculiar to Lincolnshire, and its members are large and rather coarse-boned animals, the type being well suited to the soil of that neighbourhood. The Lincoln Red Shorthorn has developed from the old Shorthorn stock. They should be of good red colour and have low-pitched horns. They have a hardy constitution and fatten easily, rendering them valuable to the butcher. They possess good dairying qualities, and the milk yield, which is 52 lb. per day, has been taken up with improving results. The live weight is 1,450 lb.

(3) Red Poll

These are more particularly found in Norfolk and Suffolk, where large numbers are bred. A deep red colour is most esteemed and they are good dual-purpose animals. The milking qualities of the Norfolk poll have not received the attention given to those of the Suffolk type. The latter breed is said to yield more good quality milk in proportion to its size than any other breed in the country. The breed has no trace of horns, and has a long, light head and short limbs with a heavy body. The live weight is 1,225 lb. and the milk yield, 44 lb. The animal fattens quickly, and produces good-quality meat.

(4) Jersey and Guernsey

The Guernsey is the larger animal of the two, being yellowish or yellow and white in colour, with a white nose. The colour of the Jersey cow varies between fawn, golden or light grey, with black nose and points. Both breeds are very docile, and are exceptionally free from tuberculosis, as, in their native homes, they are kept for a large portion of their existence in the open air. While the quantity of milk yielded is not large, the strain is noted for a product rich in fat, and the animals continue yielding up to within a month of calving. Owing to the high fat content of their milk, it has become the practice of many producers to add two or three animals of this breed to their herds, with a view to maintaining the fat percentage of the bulk supply. The milk of these animals is much sought after for the feeding of infants and children, and indeed, prior to the War, was, in many cases, sold at a specially increased price for this purpose. They are difficult to fatten, as they require large quantities of food, and so are of little value to the butcher. The live weight and milk yield of the Guernsey is 1,010 lb. and 36 lb. respectively, while the Jersey has a live weight of 850 lb. with a yield of 39 lb.

(5) Kerry and Dexter Kerry

These are natives of county Kerry, in Ireland, where the breeds have existed for a long period. They have hardy constitutions and can make good progress on poor pastures, being useful animals for the owner with poor land and slender means. They give a good-quality milk, which is preferred by many people to that yielded by Jersey and Guernsey cows. The commonest colour is black, although red is not unusual. These breeds are said to be immune from milk fever. The live weight of the Kerry is 870 lb. with a milk yield of 35 lb., while the Dexter Kerry has a live weight of 690 lb. with a milk yield of 30 lb.

(6) Ayrshire

This is the Scottish dairy cow which possesses a well-deserved reputation for being a good milker. They have small teats and the horns are of fair size, growing upwards and outwards and turning back towards the tips. They have slender forequarters and wide hips, and the general colour is white, shared with red, brown, yellow or black markings. They are hardy animals, and are more easily fattened for slaughter than the Channel Islands breeds. The live weight is 1,050 lb. and the milk yield, 45 lb.

(7) Welsh Black

These are found generally in all parts of North Wales, and are small hardy animals, long and low in the body, with fairly heavy shoulders, Their long horns are characteristic of the breed, and they are entirely black, with the exception of a few white markings on the udder. They give a fair quantity of milk which is of good quality, but, apart from figures obtained from special herds, the yield figures cannot be said to be reliable. The South Wales type has an all-black udder and the horns are yellow.

(8) Friesian

This breed is of Dutch descent and is favoured by many producers, particularly in the south-eastern portion of this country, although their distribution has now become more widespread. They are black and white in colour, have an excellent constitution, and give a large quantity of milk, the approximate yield being 55 lb. This is the largest quantity given by any breed in the country. Many of them yield 1,000 gallons per year with the first calf, the quantities increasing as the animal matures, but the quality of the milk is not very high, this animal being a case of quantity before quality. They are horned, and are long and broad in the rump, with a long head and broad muzzle. The live weight is approximately 1,350 lb. Many producers keep mixed herds of Friesians and Guernseys or Jerseys to obtain quantity of milk with quality.

(9) The South Devon

This breed is very popular in the south-western portion of this country, and possesses several good qualities which make its members highly esteemed and will no doubt result in their becoming even more popular. The live weight is 1,570 lb. and the animals give a large yield of good quality, the approximate amount being 50 lb.

(10) The Hereford

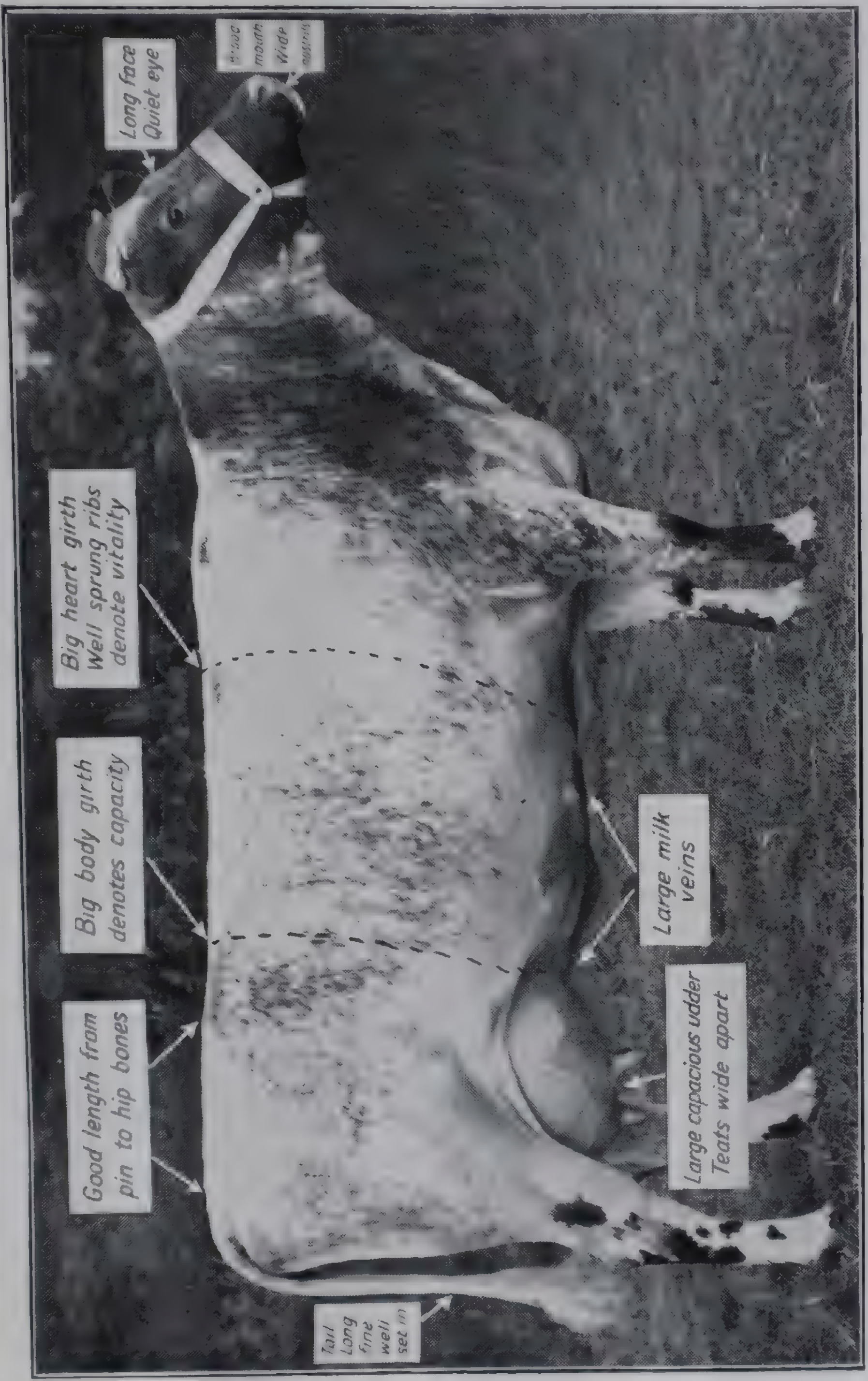
This breed excels as a meat producer, but, by careful selection of good milking strains, good dairying cattle have been produced, although cross-breeding yields even better results in this direction. It is not, however, a heavy milker, nor is such milk to be rated very highly as regards quality.

The Purchase of Dairy Cows

Although it is preferable that the milk producer should rear his own stock from what he knows to be healthy and productive animals, it is often necessary to purchase animals from various sources, reputable and otherwise. In selecting cattle for dairy purposes and with milk-selling as the object, cows which yield a large volume of milk should be chosen, provided, of course, that quality is present as well as quantity. The basis of all selection should be the breeding, health, and milk-producing powers of the animal, and although, when buying pedigree stock, full details as to milk records are generally to be obtained, this is not always possible with cows bought in the open market or even from other sources. In purchasing dairy cows of any pure or crossed breed, careful attention should be paid to the following points :

(1) The animal should possess an angular frame, carrying little surplus flesh, but with a capacity for assimilating large quantities of food. Fleshy animals do not indicate good milkers.

(2) A loose, pliable skin with fine hair is essentially a sign of good health. The yellow tint of the skin, which may be observed on the inside of the ears, is said to be an indication of a satisfactory milk yield.


Broad mouth Wide nostrils
Long face Quiet eye
Big heart girth Well sprung ribs denote vitality
Big body girth denotes capacity
Good length from pin to hip bones
Tail Long fine well set in
Large milk veins
Large capacious udder Teats wide apart

By courtesy of the United Dairies Ltd.

FIG. 1. Points of a Good Dairy Cow.

(3) The animal should have a fine head with a long face, clean throat, and large bright eyes. The mouth should be broad, with wide nostrils. A moist muzzle and cool horns are also desirable.

(4) The animal should have a large heart girth and chest development. Well-sprung ribs denote vitality, while width and depth of body are necessary for the

free working of the heart and lungs, to ensure free circulation of the blood. Breathing should be quiet and regular.

(5) The body should be of good girth, denoting a capacity for food and providing adequate space for digestion and reproduction.

(6) The body should possess good length from hip bones to tail.

(7) The legs should be set well apart and end in firm, shapely hoofs.

(8) The tail should be long and fine and well set in.

(9) Large, well-developed milk veins, which twist and branch from the milk wells where they enter the body, are considered to be reliable external indications of good milking qualities.

(10) The udder should be large and capacious and the teats set wide apart. The best type of udder extends well forward from the base of the teat. The quarters and teats should be uniform in size, and the teats should be of sufficient size to be comfortably handled. The skin should be thin and supple and the milk veins prominent. There should be no cleft between the quarters, and, after milking, the udder should be greatly reduced in size. Small extra teats are sometimes found on the udder, and these are said to be an indication of good milk producers. Another indication of a good milker is the fine silky hair on the back of the udder, known as the "escutcheon." This is not always a reliable guide, but is said to be accurate in the majority of cases. The animal should be carefully examined for obstructions in the teat and hard quarters. Hard quarters can be detected by handling, and each teat should be tested with a view to locating any defect or obstruction present. An animal, if quiet and docile—which traits are highly desirable in a dairy cow—will not object to anyone handling the udder or the teats when these are sound and healthy.

A lazy cow is seldom a first-rate milker. The animal should be able to rise and lie down without difficulty, should chew its cud contentedly, and should also lick itself occasionally. In buying animals in the open market, the danger of tuberculous cows being purchased is obvious. At present no guarantee is given of the freedom of any animal from this disease, as demonstrated by a recent tuberculin test, and the probabilities of such a test being carried out in the future are still remote. This is one of the reasons why the producer should rear his own cows from guaranteed stock, rather than buy haphazardly, as is so often the case to-day. The cow has become almost solely a milk-producing machine and, owing to the drain upon its resources by the production of calves and the giving of milk, it is essential that all the animal's organs should be sound and the nervous system in good condition.

Old cows are useless as milk producers, their product being poor in quality and in quantity. The best animals are those which have had two or three calves. It is therefore necessary to ascertain the age of the animal, and this is most correctly judged by the teeth, although the horns, when present, afford additional information. Teeth develop earlier in animals of good breeding, the time varying with the particular breed. At the beginning of the animal's second year the two central permanent incisors show themselves, and thereafter two teeth appear at every six months until, at three and a half years, the corner, broad teeth are showing. At six years the incisors show signs of wear and are flattened at the apex, with a dark central mark. A ten-year-old cow is definitely ageing, the teeth are wider apart, the corner teeth being larger than those in the centre. On the horns, the appearance of one ring at the base is an indication that the animal is at least three years of age. A further ring is added at each calving, each ring representing one year, counting three years for the first one. As the horns of old cows are sometimes filed before the animals are sent to market, it is not advisable to rely solely on this examination, but, in addition, to make a careful examination of the teeth.

As producers often wish to buy cows about to calve, or newly-calved cows, with a view to obtaining ready-made milkers, information on this subject is useful. In newly calved cows the muscles of the croup fall in, the udder is distended before milking and slack afterwards, and the milk is colostral in character, or what is commonly known as " beastings." Such milk is thick and salty in taste, changing to normal about three days after calving. Colostral corpuscles are present in the milk for approximately seven days, and in certain cases for a much longer period. Owing to the signs of recent birth becoming obscure after fourteen days, it is not always possible to pick out a recently calved milker. The lip of the vulva should be opened and the state of the lining noted. If a " spotty " condition is in evidence, this may indicate that the cow has calved prematurely, while a nodular appearance generally indicates a sterile animal. If the membrane is torn or inflamed, the cow has experienced a difficult calving, while a black or grey eroded surface indicates that the animal has improperly cleansed. It should be remembered that a cow which is accompanied by a calf in the saleyard is not always newly calved, as cases have been known where this has been done with a view to deceiving would-be purchasers. If it is suspected or stated that the animal is about to calve, it should be examined externally by pressing the closed fist against the abdomen on the right side, the resistance of the calf in the womb being thus ascertained. Practice makes the producer expert in this matter. The calf is more easily felt in old cows whose abdominal muscles are slack, the examination of well-nourished heifers being more difficult.

Defects in Dairy Cows

Dairy cows, when purchased, often exhibit certain defects which cause considerable annoyance and trouble. These are :

(1) Kicking.
(2) Hard Milking.
(3) Milk running from the Udder.
(4) Swishing the Tail.
(5) Sucking own Milk.

(1) Kicking

This is a very troublesome vice which in many animals occurs only at milking times. Confirmed kickers are difficult to cure unless dealt with at an early stage, as the fault is often caused by the improper handling of nervous or timid cows. With such animals, the milker may be injured, the milk pail upset, and its contents lost or contaminated. Kicking in young cows is often caused by pain during milking, and can only be overcome by time, patience, and the eradication of the causal agent. Confirmed kickers should be eliminated from the herd.

(2) Hard Milking

This is due to the sphincter muscle closing the teat canal, and may be brought about in several ways. As an instance, animals do not let down their milk so easily for male milkers after having previously been milked by women. Again, in some animals the cause is a holding up of the milk secretion prior to the milk entering the udder. In such cases, the milk does not actually enter the udder, the vessel being flabby and slack. This often occurs in old cows. Cows which are difficult to milk require sympathetic treatment, and it is often necessary to put a hard milker on the animal. It will generally be found that such animals are not good milk producers.

(3) Milk running from the Udder

This is the reverse of hard milking, and is due to weakness of the sphincter muscle controlling the exit of the milk from the udder. Improvement may be effected by milking the animal more frequently or by ringing the teat of the quarter affected. Collodion is sometimes used to seal the opening at the tip of the teat.

(4) Swishing the Tail

This practice may lead to contamination of the milk, and is also most unpleasant for the milker. The only remedy is to tie up the animal's tail until milking is completed.

(5) Sucking own Milk

This is a most objectional practice in some cows. Animals with this vice suck either their own milk or that of their companions. Such animals should be muzzled or eliminated from the herd.

Milk Production

By means of scientific management cattle have given enormous quantities of milk, much more so than would have been the case had the animals been left to their own devices. The cow is virtually a machine into which grass, herbs, roots, and manufactured foods, together with water, are fed, with the intention of obtaining a satisfactory quantity of milk in return. The food eaten by the animal is first changed by its digestive system into a soft and liquid material, which is then absorbed and carried to the udder and so passes out in the milk. The average yield for a healthy cow is 2 to 2½ gallons per day, but yields vary from 300 to 3,000 gallons per year. The quantity and quality of the milk are influenced by certain conditions, and it must also be stressed again that the modern dairy cow has, by the process of selection in breeding, been induced to yield a supply of milk much larger than Nature ever intended. Because of this, it is possible that the energy value of the milk may have been materially reduced in the process.

Before dealing with the conditions affecting milk production, it is necessary to consider first the structure of the udder and also the formation of the milk therein. The *udder* of the cow is suspended from the lower wall of the abdominal cavity and consists of four quarters, each with a separate teat. A muscular band is attached to the wall of the abdomen which carries the weight of the udder. There are two mammary glands, one on either side of the organ. The udder is composed of small milk-producing cells arranged in groups, with milk ducts or channels leading from the groups and converging into larger channels which convey the milk to the milk cisterns, one of which is situated above each teat. The udder is also provided with a circulatory system consisting of arteries surrounding the milk cells, together with veins which convey the blood back to the body. The teats are surrounded by a muscular wall containing nerves and blood-vessels, and the remainder of the udder is composed of fatty and connective tissue. The fatty issue, if present in large amounts, is easily detected, as, when this is the case, the udder will not shrink after milking has been completed. Some cows have an additional pair of teats situated at the rear of the udder, and in some instances these have been found to be connected to fully developed secreting glands, although such cases are very rare. The flow of milk from the udder is controlled by the sphincter muscle which, when functioning properly, prevents the milk from escaping.

To obtain a good steady stream of milk from each teat it is necessary that the *teat canal* should be free from obstructions. A defective duct is sometimes the result of a fault present at birth or of injury, and the stoppage may be either partial or complete. In all cases of this description it is essential that a competent veterinary surgeon should be consulted. To overcome soreness or obstruction in the teat, a milk siphon may be used to draw the milk from the affected quarter. This instrument enables the teat to be rested until the trouble is overcome and allows physiological healing to take place.

The modern theory of the *formation of milk* is that the milk-making cells are capable of intensive multiplication and growth, rapidly changing and being dissolved into the liquid we know as milk. The materials used in the formation of this fluid are carried to the cells by the blood-stream, the constituents of milk being finally elaborated within these cells. Recent experiments have shown that the milk continues to form during the lactation period at a varying rate, according to the stage of lactation and the interval which has elapsed since the previous milking. The rate of milk formation diminishes as the udder fills with milk.

The continuous milk-making process which takes place in the udder, with the resultant distension of that organ, renders it essential that cows should be treated quietly and gently and kept under comfortable and peaceful conditions. Harsh or hurried treatment previous to and during milking interferes with the activities of the milk-making cells, and will eventually lead to a reduction in the quantity and quality of the milk yielded.

Apart from the above, the quantity and quality of the milk yielded by any cow depends upon the following factors :

(1) Feeding.
(2) Health of the Animal.
(3) Age of the Animal.
(4) Efficiency of the Milker.
(5) Intervals between Milking.
(6) Period of Lactation.
(7) Individuality of the Cow.

No attempt has been made to place these factors in the order of their importance, as, to a greater or lesser extent, they all have a bearing upon the quantity and quality of the milk produced.

(1) Feeding

The feeding of the dairy cow is one of the most important factors involved in milk production. Not only does the process materially influence the cost of production but the general health and well-being of the herd depends to a great extent upon the skill with which rations are compounded and fed.

It has been clearly demonstrated that feeding produces a very marked effect upon the yield of milk, and this factor must always be borne in mind. Feeding can never be satisfactory unless the weight of milk given by each animal is carefully recorded after each milking and the animal fed accordingly. A large quantity of milk is drawn from the animals under present-day conditions, and proper feeding is essential in order to ensure that their general state of nutrition is not impaired by the continuous drain to which their bodies are subjected. Generally speaking, all cows in the same herd may be looked upon as requiring similar treatment, but it often happens that certain cows, if properly fed, would be capable of yielding a larger quantity of milk than that normally obtained. It also happens that many dairy herds are fed very largely on home-grown, coarse fodder, which may vary considerably in quality from season to season, this being often reflected in the milk yield. The food eaten affects the quantity of the milk rather than the quality. Water is one of the prime necessities for the animal as this makes milk, assists digestion of the food, cleans the digestive tract, and regulates the body temperature. It is therefore necessary to see that the animal obtains all the water it requires. The food given must be in excess of the bodily requirements of the animal in order to obtain the greatest production of milk. Improper feeding may cause deterioration in the quality of the milk whilst improving the quantity, a practice which is often carried out with a view to increasing the quantity at the expense of the quality.

The degree to which milk is affected by feeding has been the subject of considerable investigation, and it appears that the yield and composition of cow's milk depend chiefly upon the animal's capacity to digest the food given it rather than upon the variety or quantity of food supplied. Heavy milkers can only deliver large quantities of milk at the expense of their bodily nutrition if indigestible food is supplied, and there appears to be no reliable evidence to show that the milk yield is increased or the fat percentage improved by feeding above the maximum digestibility. Different varieties of food act upon the animal in different ways. Some foods improve the body condition, some increase the yield at the expense of the fat content, and others slightly increase the fat percentage, probably at the expense of the remaining solids.

Experiments have been carried out in America with a view to discovering whether or not it is possible for feeding to improve the fat content of the milk and some success is claimed over short periods following the feeding of oily compounds such as linseed oil or Soya-bean oil. Further experiments are essential before the process can be said to be satisfactory.

Feeding has been particularly difficult since the commencement of the war on account of the rationing of concentrates and inability to obtain certain feeding stuffs such as maize meal. On the other hand, producers have discovered the advantages of silage, dried grass, kale, and straw pulp, while home-grown feeding stuffs are now produced on every farm and have been of considerable assistance in overcoming feeding difficulties.

The usual daily ration of food is divided into two parts known as the *maintenance ration* and the *production ration*, and a balanced ration is essential if a steady and satisfactory milk yield is to be obtained.

(*a*) *The Maintenance Ration.* This is supplied to satisfy the animal's bodily requirements, and is composed of home-grown roots, hay, and straw. The mixture varies according to whether the producer has a fair supply of such materials as roots or whether, being the tenant of a grass farm, he has an ample supply of hay. When balanced ration feeding is the practice, the following may be taken to represent a specimen maintenance ration :

12 lb. Hay.
6 lb. Straw or Straw Pulp.
30 lb. Roots or Kale,
or, if not available,
20 lb. Hay.

Roots should always be fed with judgment.

(*b*) *The Production Ration.* This is supplied with the maintenance ration set out above, and is given with a view to increasing the milk yield and assisting milk production, apart from the bodily requirements of the animal. The following is a specimen production ration :—

3 parts Oats.
3 parts Bean Meal.
2 parts Palm Kernel Cake.
1½ parts Linseed Cake.
1½ parts Ground Nuts.
(4 lb. are fed to each gallon of milk given.)

Sharps, bran, and cotton cake are sometimes also used in the composition of the production ration. Concentrates are still obtainable in reduced quantities but bean meal may be substituted with good effect. It should be borne in mind that greater care must always be exercised in feeding small cows than is necessary with the larger types.

Turning the cows out to grass causes a change in the quality and quantity of the milk yielded, herds often giving an increased yield of 10 per cent. to 20 per cent. when this occurs, but it should be remembered that during damp weather, pasture may be unduly laxative. *Summer feeding* is difficult, as it is necessary to measure the amount of food materials which the pasture can provide for the cow's maintenance and production requirements under ordinary grazing conditions. This is a very difficult matter, as pastures vary in quality from farm to farm, due to the soil, manuring, and management of same. Specimen rations for summer feeding, therefore, require careful adjustment by the individual farmer. The pastures should provide all the maintenance requirements of the cow throughout the entire summer, and, for the greater part of the same period, some considerable proportion of the production requrements also. It is necessary in summer to limit bulk in certain cases. With low-yielding cows no limit need be set upon the amount of grass consumed each day, but with animals giving high yields, a strict limit should be set upon the period during which they are allowed to graze, such animals being best retained indoors from 11 a.m. to 4 p.m., where milking is carried out twice daily. In summer, the production ration should be fed immediately the cow comes indoors, although, if desired, a portion may be reserved to keep the animal engaged during milking operations.

The following table illustrates a suggested scheme of summer feeding, in addition to the maintenance ration obtained from the grass :

Month.		Milk Yields.		
		2 Gallons.	3 Gallons.	4 Gallons.
May and June	Production Ration	—	—	3½ lb.
July	Production Ration	—	1¾ lb.	5¼ lb.
August	Production Ration	—	3½ lb.	7 lb.
	Decorticated Ground Nut Cake or Bean Meal	1½ lb.	1½ lb.	1½ lb.
September	Production Ration	—	3½ lb.	7 lb.
	Decorticated Ground Nut Cake or Bean Meal	2½ lb.	2½ lb.	2½ lb.
October	Production Ration	3½ lb.	7 lb.	10½ lb.

A specimen ration for the summer months might be:

1 part Decorticated Ground Nut Cake,
1 part Palm Kernel Cake,
2 parts Bean Meal,
or
4 parts bean meal or other concentrates.

If desired, 3 parts of crushed oats may be added instead of the ground nut cake, and such a ration should be fed at the rate of 3½ lb. to the gallon of milk over the estimated value of the grass. It is essential that all feeding materials should be accurately weighed and not guessed. The decorticated ground nut cake shown for August and September is an extra with a view to supplying a food rich in albuminoids during those months, when it is estimated that a pasture is capable of providing both for the maintenance and production of 2 to 2½ gallons of milk, such an extra being essential for this period. The supply of milk from cows on grass is poorest during the summer months and richest from August to February. Changes of pasture often have a beneficial effect upon the flow of milk. The grass should be succulent and not watery or coarse.

The ration fed to a dairy herd should contain adequate mineral matter. The average sample of milk contains 0·75 per cent. of minerals or approximately 1 lb. of mineral matter is to be found in each 15 gallons of milk so that it is necessary to ensure that this is replaced by the addition of minerals to the ration. Most feeding compounds incorporate certain minerals in sufficient quantity for the animal's requirements if fed according to yield so that further proprietary minerals and salt bricks are unnecessary and may be harmful to the secretion of the milk solids.

It should always be remembered, however, that feeding is only a secondary, although obviously an important, factor, where a plentiful supply of milk is desired, as the amount and quality of the milk are primarily a matter of breeding rather than of food supply. It is not possible, by any amount or variety of feeding, to change a constitutionally poor milker into a satisfactory one.

(2) The Health of the Animal

Slight indispositions are likely to affect both the quantity and the fat content of the milk yield. Many cows calve in spring, and this tends to render the milk poorer during that time. Injury, illness, and disease soon cause a serious decrease in milk yield, and milk from ailing or diseased animals should not be used. Sometimes the milk cistern becomes blocked, when the condition known as "pipe-stem" teat sets in. This generally means the loss of a quarter and a consequent loss of milk. A constriction and growth between the milk cistern and the teat sinus, known as "pebble" in the teat, often entirely impedes the flow of milk. When a cow has an abundance of milk before calving, failure to give relief often ends in the loss of a quarter or in a reduced amount of milk during the subsequent lactation. Diseases affecting the udder, such as tuberculosis, mastitis, and abortion infection not only reduce the supply, but render such milk unfit for human consumption. It has been proved that healthy animals will manufacture more milk with less feeding than unhealthy or poor cows. Flies, whilst not directly affecting the health of the animals, give rise to a certain amount of irritation in the summer months, and these tormentors, by their unwelcome attentions, cause a loss of that repose which is so essential for milk secretion.

Changes of weather, harsh treatment, and fright may upset the animal and so decrease the milk yield, while a change of milker often causes an animal to yield a decreased quantity of milk for the same reason. All milking cattle require good grooming and such grooming has a direct bearing, not only upon the health of the animal, but also upon its milk-productive powers and the quality of its yield.

It is imperative that a suitable interruption should be provided between one lactation period and that immediately following, in order to permit the animal's depleted reserves to be restored. The care of the udder of the milk-producing animal is important, as the more highly developed the organ is, the more liable does it become to specific infections and injury. Many infections are introduced into the udder by means of the teat canal, and this is facilitated by improper practices during milking. If any milk is left in the teat canal or in the milk cistern after milking is completed, an easy path is provided for external bacterial infection. The risk of such infection should be prevented or at least minimised by properly stripping the udder at each milking. The proper stalling of the animals, each cow being kept separate, will minimise the risk of injury to the udder of any one animal by its neighbours.

Producers are advised to take advantage of the Panel Scheme for Animal Health now in operation throughout the country. For an annual fee of 9*s*. per animal, each cow is clinically examined by an expert veterinary surgeon four times each year for the presence of the following diseases :—

(*a*) Contagious Abortion.
(*b*) Mastitis.
(*c*) Johne's Disease.
(*d*) Sterility.

In 1943, 6,000 producers were taking advantage of the scheme and the number is increasing at the rate of 100 per month. It is to be regretted that the response to the facilities afforded has not been more general, although it must be stated that if all producers entered the scheme there would be insufficient veterinary surgeons to operate it successfully.

(3) **Age of the Animal**

The age of the animal is an important factor in the milk yield. As a general rule, the yield of a cow increases up to seven or eight years of age, after which time it decreases. In exceptional cases, especially where a cow has been well looked after, this may not be the case. The highest yield will usually be obtained following the birth of the fifth or sixth calf. It may be assumed, given similar conditions of management, that a cow with a first calf yielding 700 gallons of milk per year will yield 800 gallons with its third calf and 1,000 gallons with its fifth or sixth calf. It is necessary to concentrate on acquiring young herds, that is, cows of three to five years of age, in order to avoid obtaining milk below the required standard. Young herds possess the added advantage of being less liable to tuberculosis.

(4) **Efficiency of the Milker**

The object of the milker should be to obtain the milk from the udder, milking each quarter speedily, quietly, and thoroughly, with as little disturbance as possible. Milking carried out in this way is an aid to obtaining an increased yield and a high percentage of fat.

Physically, milk removal depends upon the pressure exerted on the sphincter muscle in the teat, which is released by the action of the fingers of the milker, thus allowing the milk to flow. The teat should be grasped firmly and the hand kept close to the udder. Some milkers adopt a jerky, pulling action, which is quite unnecessary and should be discouraged, as, if persisted in, the practice may lead to injuries, obstructions, or misshapen teats. It is imperative that the milker should handle the cow gently, so that it lets down its milk freely. For this reason women, who are usually gentle in their handling, make good milkers. Care is particularly necessary with young animals during the first lactation period.

There is no rule as to which teats should be milked first, but, speaking generally, it is found most convenient to milk the teats on the farther side of the animal with the right hand, and milk either the hind or fore teats together. Teats at opposite corners of the udder should not be milked simultaneously, as in this way the udder will swing and impose a jerky strain upon the muscles which attach it to the body. In cows with the first calf it is a common practice to milk the weaker quarters first, with a view to obtaining a balanced udder. The average milker will usually milk some eight cows per hour, but the really efficient milker will probably deal with ten in the same time.

Stripping is very important. This is the removal of the last milk remaining in the udder, and is carried out by stroking the teat with the thumb and first finger, commencing at the base of the teat and working towards the orifice. The last-drawn milk is always richest in fat. The great importance of completely emptying the cow's udder at each milking should therefore be borne in mind. A brief upward pressure against the udder should be applied before each strip, so that the largest quantity of milk can be forced down. Imperfect removal of the milk causes the yield to fall off quickly, when the article will have a low fat content. As already indicated, such a practice is often the cause of diseases in the udder. Sometimes producers, wishing to dry off cows, do not milk the animals full out. This may cause mastitis, and should be avoided whenever possible. The best way to dry off a cow is to milk less frequently, always taking care to strip the udder properly at each milking. During the drying-off period the food should be such that it will not assist in the production of milk. As it is almost impossible to stop milk secretion when the animal is out to grass, it is necessary to tie up the beast in a loose box or pen until thoroughly dry. Constipation should be guarded against, and purgatives should therefore be given before steps are taken to lessen the milk flow.

(5) **Intervals between Milking**

The interval between the morning and evening milking has an important bearing upon the composition of the milk yielded. Where the intervals are equal, the composition of the two milks should be approximately similar, except that in such a case the morning milk would probably be slightly richer in fat. Some producers milk their animals three times a day, but such a procedure is the exception rather than the rule, although, in the case of very heavy-yielding cows, this practice possesses certain advantages, inasmuch as it relieves the pressure on the udder. It is probable that many more farmers would adopt the practice if they could organise their labour so that the system could be made to work satisfactorily. In any case, the method is one which could only be adopted with any success on highly specialised dairy farms. In this country the period between morning and evening milking is much shorter than between evening and morning milking, with the result that the higher yield of milk is obtainable in the morning, while the higher fat percentage is obtained in the afternoon or evening milking. Although the variations in milk solids other than fat are very slight, the fat content variations are often considerable, even in the same cows. It is safe to say that the unequal intervals between milking as practised in this country cause great variation in the quality of the milk produced, which point should be carefully watched by the producer. If it is found that the fat percentage in the morning milk is dangerously low, the intervals should, wherever possible, be equalised The heaviest-yielding cows milked last in the afternoon should be milked first in the morning, and a milk equaliser should be used to ensure uniform distribution amongst several churns.

Apart from variations caused by unequal intervals in milking, *seasonal variations* also occur. Winter milk is generally of the highest quality, while summer milk is poorest. Spring and autumn are transitional periods.

(6) **Period of Lactation**

The effect of the period of lactation upon the milk produced by each animal may be divided as follows :

(*a*) *Effect upon Yield.* After the animal calves, the yield of milk increases quickly and considerably until the maximum is reached, generally in the fourth or fifth week after calving. Well-cared-for and well-fed cows, however, may not attain their maximum until the sixth or seventh week, and such animals often show little diminution until four or five months have elapsed. In average animals a slight decrease in quantity becomes apparent three months after calving, and the fall is then gradual until the cow goes dry. The average lactation period of a cow producing one calf per annum is 43 weeks, and the average dry period is 9 weeks. The period of rest should never be reduced to less than 6 weeks, or the yield during the following lactation may be materially decreased. The rate at which the yield declines is often affected by the feeding. The effect of pregnancy is usually seen in a falling-off in the milk yield after the twentieth week.

(*b*) *Effect upon Fat Percentage.* The percentage of solids in milk, especially fat, is lowest at the time of the animal's highest yield. With ordinary well-fed cows the percentage of fat increases as the yield decreases until the animal goes dry.

Long lactation periods, with considerable periods of rest and good feeding, will increase the yield of milk. The business-like producer will wish to have in his herd cows which calve at varying periods to ensure a constant supply of milk during the entire year, the aim being to have the largest quantity of milk for sale when supplies are generally reduced and prices highest.

(7) **Individuality of the Cow**

The individuality of the animal has a direct bearing upon the milk produced, the milk of some cows being richer in quality or greater in quantity than that of others. This occurs apart from age, breed or period, of lactation. When animals are discovered giving a high yield of milk with a good fat content, they should be used for breeding purposes and their progeny brought into the herd. Another important factor affecting the actual yield of the animal is the condition under which it has been brought to maturity. All animals may be born with certain inherent possibilities, but whether or not these are realised depends to a certain extent upon the conditions under which the animal develops or matures. It frequently happens that an animal, owing to poor management, does not yield the performance expected of it, although it may be the bearer and the descendant of good progeny.

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In spite of this, a knowledge of heredity will reveal the fact that, while correct management and environment may affect the development of an animal's inherent qualities, the dominant characters which it possesses are established at birth.

BEDDING

Suitable bedding should always be provided for the animals. If this is clean and soft, it promotes comfort and cleanliness, and has a decided value. It also serves to overcome any danger of slipping due to concrete floors, while certain other disadvantages held against this type of flooring can usually be ascribed to lack of sufficient bedding. *Straw*, which is now extremely plentiful, *sawdust*, and *peat moss* are all used in this country for bedding purposes, each type having its advocates. Bedding, of whatever kind used, should be free from any element likely to endanger the health of the animal. Moulds, fungi, and pathogenic organisms should be excluded so far as is possible. The provision of a thick layer of bedding affords a protection for the knees and feet of the animal and also facilitates the easy removal of wet or soiled material.

MILK RECORDING

The practice of milk recording and testing for butter-fat percentage is now fairly widespread, the latest figures indicating that one cow in every nine is recorded, while the number of recorded herds is increasing month by month. Such recording, which is a paying proposition to all dairy farmers, possess the following advantages :

(1) It enables unprofitable cows to be detected and they may be removed from the herd. It is impossible to differentiate between profitable and unprofitable animals by guess-work only.

(2) Feeding may be carried out in a more economical manner. A cow requires to be fed according to age, size, and amount of milk yielded. It is quite possible to feed a cow expensively and yet not obtain any better results than could be procured from cheaper foods. Vast amounts of food are wasted daily by being fed to cows which are thoroughly unprofitable both to their owners and to the country, and the food consumed by such animals could more profitably be given to some cow that was being underfed.

(3) Any reduction in the yield, however slight, is immediately detected, when the cause can be investigated in the particular animal affected. In this way a sick animal may be brought to light earlier than would otherwise be the case.

(4) The effects of change of food and climatic conditions can be noted.

(5) It adds to the interest of milking.

(6) It places a definite check upon the work of the milker.

(7) From the milk records of each animal the breeding, selection, and feeding of dairy cows can be conducted in an intelligent manner.

Selection of animals for type has been disappointing from the point of view of the breeder of dairy cattle, and for this reason such breeders now work on a performance basis, taking into account milk and butter-fat yields, those being factors which are capable of exact measurement. Milk recording enables the poor milk producers to be detected, and these cows can then be removed from the herd and replaced by others more suitable. Good herds can be safely built up by the intelligent use of the information to be derived from the records so obtained.

It is advisable that the weight of the milk given by each animal should be recorded immediately after milking. This may also be recorded once daily with satisfactory results. Weekly, fortnightly, and monthly recordings are sometimes made, but do not yield such reliable information. The milk is weighed in the milking pail, the weight of which is already known, on a spring balance provided with a register dial. The weight of the milk is then recorded on the chart provided for the purpose. It is also advisable for the producer to sample the milk, either from each animal or from the bulk supply as required, for butter-fat. He may, if he so wishes, carry out the examinations himself by means of the simple apparatus described in detail in Chapter X ; or they can be carried out for him quite cheaply at any of the Agricultural Colleges mentioned on page 190 or they will be carried out by the Milk Marketing Board who are now sponsoring the Scheme.

Every progressive dairy farmer should record his milk as a member of the National Milk Recording scheme. Recording will enable a marked improvement in the average milk yield of the herd to be shown in two or three years following its introduction. It must be emphasised, however, that results are likely to be disappointing unless a good bull is used for breeding purposes. There is little doubt that the study of animal type and the relation of body characters to performance as regards milk yield has been the foundation of our dairy stock improvement.

DISEASES OF DAIRY CATTLE

Dairy cattle are subject to a variety of diseases and it must be emphasised that the average productive life of a dairy cow in this country is curtailed to approximately 4½ years by numerous ailments which are responsible for losses amounting to several millions of pounds. In addition, the loss in the annual productivity of the cow during life which would follow if such diseases were eliminated from dairy herds must also be taken into account. Not all these diseases are serious, and it is only necessary in a volume of this character to mention those which may affect the health of the consumer owing to the presence of their causative organisms in the milk supply. The diseases in question are :

(1) Tuberculosis.
(2) Mastitis.
(3) Cowpox.
(4) Foot and Mouth Disease.
(5) Actinomycosis and Botriomycosis.
(6) Anthrax.
(7) Rabies.
(8) Contagious Abortion
(9) Milk Fever.
(10 Digestive Affections.
(11) Sore Teats.
(12) Sterility.

(1) Tuberculosis

This disease is very prevalent in the dairy herds of our country. It has been estimated by various reliable authorities that the incidence of tuberculosis in all degrees among dairy cows is not less than 40 per cent., an enormous percentage in what are primarily food-producing animals. All animals affected with this disease do not necessarily secrete tubercle-infected milk, although examinations of various types of market milk in different areas have proved that between 6 and 7 per cent. of such milk contains living tubercle bacilli. The importance of the high percentage of cattle affected by tuberculosis in some form or another lies in the fact that, although the animals may not be secreting infected milk at any given time, they are potential infective agents. Further, there is no indication that bovine tuberculosis is decreasing, while there is also no evidence to show that bulked raw-milk supplies possess a reduced percentage of the organisms of this disease.

Methods of Infection

Infection generally takes place through the living bacilli, discharged in some manner by a diseased animal, being absorbed by a susceptible contact. There are three ways in which this infection may take place :

(*a*) *By Inhalation.* The bacteria may be inhaled by a healthy animal from the respirations of an affected neighbour which contaminates the air of the cowshed. In moist, warm atmospheres, the surroundings of a badly affected animal provide one of the most certain sources of infection. Dried particles of infected dung may be disseminated in the air of the cowshed by the movement of a manure covered tail, and this dust may be inhaled by other animals.

(*b*) *By Ingestion.* The affected animal may cough into the feeding trough, the drinking-bowl or trough, or other source of water supply, polluting the water or the food with mucous discharges ejected from the throat or lungs. In this way the infection can be easily passed on to other animals who may swallow the infective material. The licking of the wall or feeding trough after an infected animal is another source of infection. Tubercle bacilli may be discharged from the mouth or in the dung on to grassland or into the water supply, with a subsequent spread of infection. Sputum coughed up by an affected animal is often swallowed and subsequently infects the digestive system, rendering the excretions dangerous. All animals lick themselves, and the splashing of infected dung from an affected animal on to adjoining cows may cause infection of other animals whose coats are contaminated in this way.

(*c*) *By Inoculation through the Skin.* Although this is a possible mode of infection, such an occurrence is very rare.

A further way in which the disease may be introduced into the herd is by the purchase of new animals which may be suffering from latent, undetected tuberculosis. The disease, on becoming more advanced, may subsequently affect other animals. The fact that the cow has, by a process of in-breeding, become a super milk-producing machine may also have some bearing on the incidence of this disease among dairy cattle, which suffer from it far more than do other domestic animals. No cow was ever intended by Nature to produce the large quantities of milk now obtained from many animals in this country. As a proof of the effect which such super milk production has upon the incidence of tuberculosis, the fact that the disease is more prevalent among heavy milk-producing breeds might be instanced. The heavy calf production of modern cattle, carried on with a view to maintaining frequent lactation periods, has also probably played its part in reducing the stamina of the animal, and thus rendering it more liable to infection.

In cattle, infection originally takes place by way of the respiratory or alimentary tract. Although in man tuberculosis is almost invariably a systematic infection in its early stages, the primary seat of infection in young cattle appears to be the alimentary tract due to their being fed on milk from tuberculous cows. In older cattle, the lesions are most frequently found initially in the lungs and respiratory tract generally.

Spread of the Disease

The tubercle bacilli, on gaining entrance to the animal's body, establish themselves and act upon the glands, tissues, and organs, producing alterations in the cells and destruction of the body tissue. Characteristic nodules or tubercles are formed. These vary in size, from small shot to a tubercle as large as the human fist. Their formation prevents the organ or part affected from functioning in a natural manner, while the toxins or poisons produced by the bacilli are absorbed into the system of the animal as the disease progresses, producing consequent further interference with its health. As the disease advances, the tubercles grow in size, eventually becoming caseous or cheesy. They may also suppurate or produce ulcers.

The disease may, for a considerable period, be confined to small areas of the lungs. As the disease advances, the infected areas increase in size until large portions of the lungs become consolidated. By means of the lymphatic channels, the bacilli are carried to the lining of the chest wall, where nodules are formed, often in large numbers. The breaking down of the lung tissue causes irritation and frequent coughing, which is one of the common clinical signs of the disease. This coughing causes the bacilli to be ejected from the air passages and the throat, great numbers passing out into the air, the remainder being swallowed and entering the digestive system, from which, in turn, large numbers are ejected in the fæces.

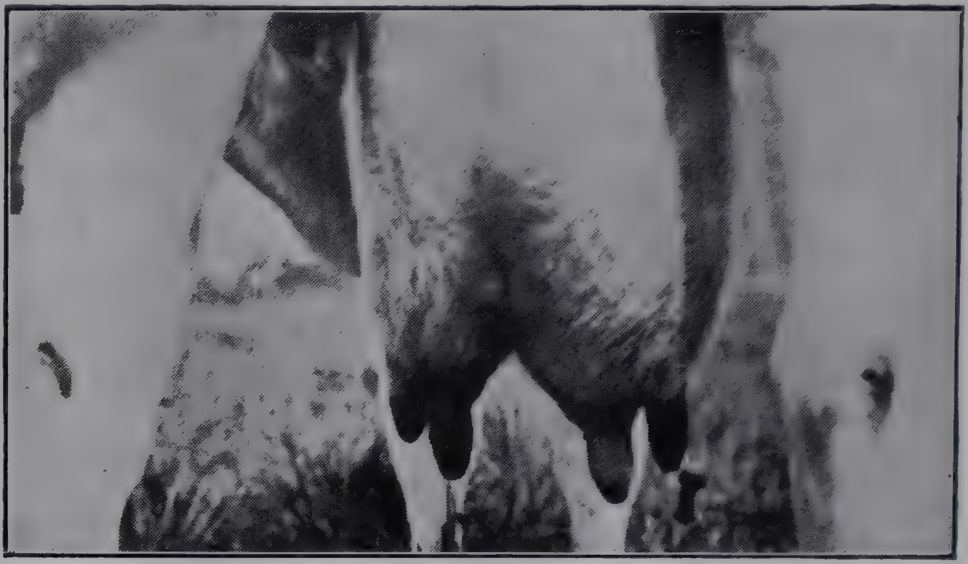
Infection of the digestive system thus follows that of the respiratory system, and although large numbers of bacilli are excreted, as described above, they do not leave the body by this route. A certain number may, and often do, pass through the intestinal wall to be carried to the lymphatic glands associated with the intestines. Here new centres of disease are set up. The infection spreads from these glands to the peritoneum, and is eventually carried by the associated lymphatic system to the udder, with a subsequent infection of the tissue of that organ. Milk from tuberculous udders is often highly virulent, although, even in animals in an advanced stage of the disease, the organ may not be affected. The liver is often affected, but the disease rarely attacks the spleen in cattle. A further organ commonly affected is the uterus, especially when the disease is in an advanced stage, but it must not be forgotten that this organ may be the primary seat of infection in an animal which has been bulled by a bull affected with tuberculosis.

It should be noted that in many cases tuberculosis in cattle is of slow growth, the infective agent being at first confined to a great extent within the body. As the disease advances the discharges from the animal become more virulent, the organisms being discharged from the mouth, nose, rectum, and udder in varying quantities. It should also be borne in mind, however, that, although the lesions and symptoms of the affected animal may be slight, the discharges from such an animal may be highly infective from an early stage.

Signs and Symptoms of Bovine Tuberculosis

Owing to the disastrous effects of tuberculosis upon the health of the animals and even upon attendants working among infected herds, it is important that the cow-owner should be able to recognise an animal affected by this disease. Not only is this essential as a means of preventing further infection of the animals, but, what is more important, such recognition is imperative from the point of view of preventing infection by the consumption of milk from such diseased animals. When the disease is recognised, the animal affected should be removed immediately from the herd until seen by a veterinary surgeon, the appropriate authority should be notified without delay, and the milk should not be sold for human consumption. Unfortunately, the symptoms of tuberculosis in its early stages are not very distinct. *Coughing*, particularly noticeable when the animal is in the open or during exertion in the cold air, is frequent. Sometimes the cough becomes very noticeable when the animal is drinking cold water. *Troubled breathing* (dyspnœa), a certain degree of *anæmia* and, in the later stages, *wasting*, are also noticeable. Food is often refused in the later stages of the disease, the cough becomes more frequent, and the throat may swell. In the case of an abdominal infection, *diarrhœa* may be present together with *colic pains*, and *slime*, *pus* and *blood* may be present in the excretions. When the kidneys are affected the *urine* is thick and strong smelling. Cases of the disease often run a mild course, hardly any of the usual symptoms being noticeable. In such an instance, the only reliable method by which the affected animal may be detected is through the use of the tuberculin test. Full details of the various methods of testing are given later in this chapter (see page 62).

As the disease further advances the general physical state of the animal deteriorates rapidly. It loses its condition, the neck, ribs, and flanks, which in healthy animals are well filled out, sink in, and finally *emaciation* is extreme. It is almost superfluous to add that the signs of disease should be recognised by the owner long before the condition of the animal reaches this stage.

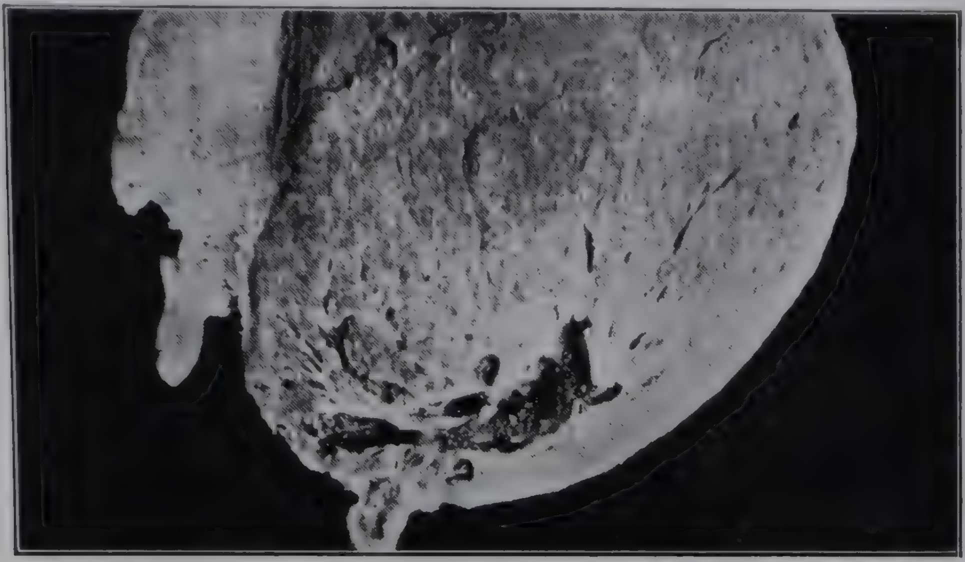


By courtesy of the United Dairies Ltd.

FIG. 2. A Tuberculous Udder.

In dealing with this disease it will be readily understood that the *udder* of the affected animal is the most important organ to be considered in the control of the milk supplies. The disease does not, as a rule, infect the udder until an advanced stage has been reached. On the other hand, tubercle bacilli have been demonstrated in milk from udders which show no perceptible evidence of the disease, while the organisms may be present in sufficiently large numbers in the milk from such udders to render the product highly dangerous to the consumer. It should also be remembered that the presence of these organisms in the milk is not constant, but varies from day to day. In the udder, either one or both hind-quarters are first affected. The affected quarter begins to *swell*, the swelling being hard and painless. As the disease advances the growth steadily progresses and the swelling may be irregular, knotty, or well-defined. The swollen part is usually very hard, and, owing to the excessive growth of fibrous tissue, the affected quarter may become completely *indurated*. After milking the affected quarter right out, *little hard nodules* may be felt within its substance. The *glands* at the rear of the udder, if palpated, will be found to be enlarged and hard.

Tuberculous disease in the udder affects both the physical and chemical properties of the secretion. The composition of the milk is at first normal, but, as the disease advances, the secretion from the affected quarter or quarters becomes thin and watery and is often of a yellowish hue. Later, white flakes or lumps may be found in it. Milk is produced by filtration and secretion in the udder, and the cells present are concerned in these processes. Following infection they lose their integrity, with the result that the fluid is poor and the quantity decreases, fat, casein, and lactose being also diminished. A microscopic or biological examination of the milk from suspected quarters will thus determine whether or not the udder is affected.



By courtesy of the United Dairies Ltd.

FIG. 3. Section of Tuberculous Udder.

Eradication of Tuberculosis from the Herd

It should be borne in mind that the chief factor in the spread of the disease among other animals of the herd is tuberculosis of the lungs, and from affected animals to the human subject the existence of animals with diseased udders. The removal of affected animals from the herd should never be a matter for regret on the part of the producer, as such animals would soon be unprofitable and would probably, in addition, render other animals useless. Prevention is always better than cure, and there are certain definite ways in which the disease may be prevented. The *overcrowding* of animals under insanitary conditions is likely to assist in the spread of the disease, and the presence of an affected animal under such conditions will favour the infection of the other animals. Good, well-lighted, sanitary buildings, while of paramount importance, are not, however, sufficient to eradicate tuberculosis from an infected herd, as even in good cowsheds the disease has been known to spread rapidly, due to the presence of affected animals. This shows the importance which must be attached to the *immediate removal* of the affected from the healthy animals. *Calves* should be removed from suspected animals and fed on milk which has been pasteurised or boiled. *Common feeding-* and *drinking-troughs* assist in the spread of infections, as does the excreta evacuated by the affected animals. *Fowls* should on no account be allowed in the cowshed. The frequent cleansing and disinfection of cowsheds is a necessity, especially those portions likely to be contaminated by mucus from the lungs or by the fæces.

The estimated percentages of affected animals and of those giving infected milk have already been mentioned, and when it is realised that those affected animals which are not giving infected milk are also potentially dangerous, some definite, constructive method of eradicating the disease becomes essential. Tuberculosis would be quickly eradicated if expense were no object, but up to the present financial difficulties have allowed of little progress being made. Various schemes have been put forward from time to time with this object in view, and most of these involve the use of the tuberculin test. Six methods have at one time or another been advocated as a means of eradication :

(*a*) **Tuberculin Testing of all Herds.** From an economic point of view this method is expensive, and particularly is this so when it is remembered that compensation would have to be paid for the reactors which were slaughtered. As a means of eradication, however, it would be ideal, as the disease has entirely disappeared from herds following its use in quite a number of cases, sometimes indeed with comparatively small expense. Apart from the question of individual expense, the logical result of this method would be the slaughter of almost half the dairy animals in this country, if the estimated percentage of affected animals is correct, and investigations made by various reliable authorities have proved that this is the case. This would cause a very serious decrease in the quantity of milk available for public use, which in turn would cause a dangerous rise in prices. To envisage such a method in practice is extremely difficult, although it would probably be ultimately successful for the following reasons :

(1) It has proved highly efficient and successful in application, particularly in America, although there is not nearly so high a percentage of affected animals there.

(2) It is a straightforward system and simple to control.

(3) Tuberculin testing discovers animals in the early stages of the disease, in addition to the more advanced cases. Reactors in the early stages are worth more when slaughtered as salvage, and this method would prevent the serious wastage which takes place with the slaughtering of advanced cases.

(4) The early removal of infected animals prevents the disease spreading to other members of the herd.

(*b*) **Bang's Method.** This method is one which might well be adopted for use in this country, should complete eradication of the disease ever be attempted. The process is briefly as follows : All the animals in the herd are clinically examined, and any showing evidence of disease are removed and slaughtered. The remainder of the herd is tuberculin tested, and the reactors are segregated from the healthy animals. It is essential that the reactors should be completely isolated, and for this reason a separate cowshed should be provided, although, if this is not economically possible, the existing cowshed can be divided into portions by the erection of a brick partition. Care must be taken, in housing the two portions of the herd in one building, that the drainage of the non-reacting portion always flows towards the reacting portion in order to prevent the risk of the disease being carried to the healthy animals by means of the urine and manure in the gutter. Separate attendants, grazing ground, and water supply should also be provided for the two portions of the herd. Clinical evidence of the disease in any of the reactors renders it necessary for the affected animal to be immediately slaughtered. The calves of the reactors are tuberculin tested and any reactors removed and slaughtered. This is a very rare occurrence, as practically no calves are born with the disease, such being generally acquired at a later date. Calves of the reactors are weaned after twenty-four hours with the cow, and are fed on milk from healthy cows. They eventually live in the open until required for breeding purposes and are most likely to remain free from the disease.

The free herd is re-tested with tuberculin every twelve months, and no newly bought animals are admitted until clinically examined, tuberculin tested, and proved to be non-reactors. The entire procedure is designed to replace reactors with healthy incoming stock, the result being that in time a herd is built up which is free from the disease. The advantages of such a method are :

(1) The tuberculin test, which is at present the only satisfactory method for discovering reactors, is the basis of the scheme.

(2) It is not so expensive for the owner of the herd as the previous method, since the rate of progress can be arranged to suit his financial position.

(3) The infected animals are not quickly reduced until healthy stock take their places.

It has, of course, the disadvantage of being a slow method, while, to be a complete success, the two portions of the herd must be properly segregated one from the other. The question of the disposal of the milk from the reacting cows must also be considered. As already stated, the idea of this method is to build up a healthy herd by the gradual weeding out of reactors. All reactors do not give tuberculous milk, although some may do so, and the destruction of all milk from reactors would mean a serious decline in the quantity of milk available for human consumption. Milk from reacting animals might, of course, be efficiently pasteurised, when it could be sold to the public with safety.

(*c*) **Ostertag's Method.** In this case the tuberculin test is not applied to the herd as a whole. All the animals are clinically examined, and those showing signs of the disease are at once slaughtered. Weaned calves are fed on sterilised milk, tuberculin tested, and the reactors slaughtered. Calves free from the disease are segregated from the remainder of the herd during their entire life, even in the adult stage. The remainder of the herd is clinically examined at intervals, and frequent samples of milk are taken from each animal for biological examination. Any animals showing positive results are removed from the herd and slaughtered. The idea of this method is to prevent, so far as is possible, the infection of the healthy animals in the herd, and also to encourage the rearing of an entirely separate healthy herd out of reach of infection. The existing herd is used in the meantime to maintain the milk supply, while the healthy herd is being attained. This method has not found much favour outside Germany, owing to the fact that it has been found to be of little use in reducing bovine tuberculosis added to which is the expense of veterinary services, bacteriological examinations, and supervision which it entails. It follows closely the action taken under the Tuberculosis Order of 1938, described below.

(*d*) **Action under the Tuberculosis Order, 1938.** The aim of this Order is to eliminate advanced cases of disease by means of compulsory notification and subsequent slaughter of the animals. Under this Order, the following forms of the disease are notifiable :

(1) Any cow which is, or appears to be, suffering from tuberculosis of the udder, indurated udder, or other chronic disease of the udder ; or

(2) Any bovine animal which is, or appears to be, suffering from tuberculous emaciation ; or

(3) Any bovine animal which is suffering from a chronic cough and showing definite clinical signs of tuberculosis.

The milk of the diseased cow must not be mixed with other milk until the cow has been seen by a veterinary surgeon, and the milk must either be destroyed or boiled and given to other animals. The containers used for such milk must also be sterilised.

Although the Order was brought into operation several years ago with the best of intentions, these intentions have never appeared to be near realisation. If animals which show clinical signs of the disease are not promptly notified and dealt with, there is a serious risk of the spread of infection among the remainder of the herd. The percentage of infected animals in the dairy herds of this country has not decreased since the Order became operative, owing to the fact that highly infective animals are not removed from the herd until it is too late to prevent the spread of infection to others. It would therefore appear that this Order, even when supplemented by adequate clinical examinations, has done, and will do, little towards reduction of the number of diseased, milk-producing animals. Further, it must be admitted that clinical examinations as carried out in this country cannot be said to be entirely adequate. To be satisfactory, at least quarterly inspections of every herd would be necessary, and this at the present moment is an impossibility. If such examinations were practically possible, the result would be that :

(*a*) Cases of tuberculosis of the udder and other diseases of that organ would be more quickly discovered.

(*b*) The poorer type of cow would become a rarity.

(*c*) Cases of tuberculous emaciation would become few in number.

Even if such inspection were carried out, however, with a consequent reduction in the danger from the milk supply, the system would never render the milk entirely safe. There are thus two main reasons underlying the ineffectiveness of the Order :

(1) Notifications are generally made too late to eliminate all the animals which may have been a source of infection to others for some considerable time.

(2) Clinical examination fails in many cases to detect udders from which the milk is highly infective.

Many of the animals are detected only when samples of milk are taken by local authorities, biologically examined, and proved positive, but the number of authorities who carry this out consistently and in a proper routine manner are very few. The number of clinical inspections made varies. In a few counties the inspections are made quarterly, in some biannually, but generally they are made annually. The Report of the Milk Reorganisation Committee suggested that such inspections should be made three times a year and no doubt much good would result from such a routine inspection if it were properly carried out. The Order, as at present administered, is of very little service, and largely a waste of public funds. To improve the chances of its success, the following amendments are suggested as essential :

(1) An extension of the Order to provide for animals exhibiting clinical signs only, without accompanying symptoms, to be notified.

(2) Suspected cases to be notified by owners, under penalty to be incurred if affected animals are subsequently discovered as a result of the biological examination of the milk supply.

(3) A much more adequate veterinary service to be provided, with subsequent slaughter of all clinical cases.

(4) Compensation scale to be altered to penalise any undue delay.

(5) Suspected animals to be isolated and the milk destroyed until proof of infection is established (a period of approximately six weeks). Isolation to be controlled under responsible supervision.

(6) Routine system of sampling for biological examination to be adopted by *all* local authorities, and such a scheme to receive financial aid if necessary.

(*e*) **Milk (Special Designations) Order, 1936.** The intention of this Order and that of the Order of 1923 was to secure the voluntary eradication of the disease from individual herds, thus enabling a high-grade milk to be marketed. The elimination of tuberculosis from the country's herds was an admirable idea, but it is to be regretted that only a small percentage of the total cow population of the country are tuberculin tested under its provisions. Apparently the testing and clinical examination of these special herds is not always sufficient to prevent the organism of tuberculosis being present in the milk, as this has been found to be the case on several occasions. The Order as a means of reducing tuberculosis has made slow progress, and cannot be said to have achieved the success which it deserved, probably for the following reasons :

(1) The small number of producers who have adopted the principles of the Order.

(2) Cost of licence fees.

(3) Cost of tuberculin testing and veterinary fees.

(4) The poor demand for such milk.

(*f*) **Immunisation.** Koch, many years ago, demonstrated the fact that animals already suffering from the disease or infected by the tubercle bacillus were more resistant to subsequent inoculation than those free from infection or disease. As has been the case with human infection, many investigators have attempted to solve the problem of immunisation, but the chief difficulty has been to find a vaccine which possessed immunising properties but was harmless to the animals so inoculated. In 1920, Calmette and Guerin described a method of vaccinating young stock against infection, and this system has prospects of being of material use in the elimination of tuberculous disease. The vaccine used is known as B.C.G., and consists of living tubercle bacilli whose virulence has been attenuated by prolonged sub-culturing in the laboratory on media containing bile and glycerine.

Inoculation by this method is said to lead only to the creation of a small tubercular focus which shows no tendency to extend, and in which the inoculated organisms quickly die. The inoculation is also claimed to give the animal a life-long immunity from natural infection. Although a large number of experiments have been made in many countries, the results have not always fulfilled expectations, while being in many instances encouraging. It may be that differences in the breeds of cattle used for experimental purposes have had a bearing upon the results obtained, as there may be, and probably are, differences in the susceptibilities of the cattle of various countries to tubercular disease. In Calmette's experiments, immunised calves were housed with cows which showed obvious clinical signs of the disease for a period of nearly three years, and the experiments proved that the vaccinated animals acquired a high degree of immunity against infection. Tests have been carried out in this country with a view to ascertaining the ultimate practical value of B.C.G. vaccine and also with Spahlinger's method, but such tests have not been entirely satisfactory. As immunisation holds out a possible solution to the difficulties which exist in controlling the disease, much more investigation could profitably be carried out along such lines. If it could be proved that a vaccine, whilst being perfectly safe in use, gave lasting immunity to cattle, it would be of considerable value, as, by its aid, bovine tuberculosis in cattle might be eradicated in a few years at comparatively small cost.

Tuberculosis and the Tuberculin Test

In practice, the simplest way to free a herd from tuberculosis and to keep it free is to remove any animal reacting to the tuberculin test from the herd, thoroughly disinfect the cowshed, and repeat the test at regular intervals. Congenital tuberculosis is very rare (0·04 per cent. of newly-born calves), but the percentage of cows reacting to the tuberculin test is often very large when a herd is first tested. When the producer has secured a tubercle-free herd he should be self-supporting, breeding his own animals from healthy stock.

The tuberculin test may be applied in one of three ways, either separately or combined. These are as follows:

(1) Subcutaneous.
(2) Ophthalmic.
(3) Intradermal.

Before the application of any of these tests, the animal should be rested for twenty-four hours, as digestive and other physical disturbances may prejudice the application of the tests.

(1) *Subcutaneous Test.* This test, invented by Koch in 1890, is carried out by injecting 4 cubic centimetres of tuberculin subcutaneously into the animal's neck immediately in front of the shoulder region. The temperature of the animal is taken two days prior to the injection being made, at the time of the injection, and at 9, 12, 15, or 18 hours subsequently, as is considered necessary. Normal temperature is 102° F. to 103° F., a temperature of 103° F. to 104° F. being taken as doubtful, while 104° F. or over is regarded as a positive reaction. This test, while definitely useful, possesses one disadvantage. If a cow is injected with tuberculin some short time previous to any authorised injection, the animal, even if tubercular, will not react. This does not occur with the use of the intradermal test. It is possible, by means of the subcutaneous test, to detect a large proportion of affected animals. Parker states that, of 50 animals tested by this method in Northumberland, the results were accurate to the extent of 78 per cent.

(2) *Ophthalmic Test.* To carry out this test, 2 or 3 drops of concentrated tuberculin are injected into the eye. If the reaction is positive, the conjunctiva becomes congested and the congestion is accompanied by a mucous discharge from the corner of the eye. This is not a reliable test unless used in conjunction with one of the other methods described.

(3) *Double Intradermal Test.* In this test, two injections are made, the first being named the *sensitising* dose, and the second, which is usually carried out after an interval of 42 to 72 hours, the *diagnostic* dose. The site of inoculation generally chosen is in the centre of the left side of the neck. An area approximately 4 inches by 3 inches is shaved clean of hair, and the injection made in a horizontal direction in a fold of the skin. The quantity injected is approximately 0·1 cubic centimetre, or roughly 1½ drops. The result of the injection is immediately evidenced by the formation of a small pea-like swelling at the site of inoculation. A measurement of the skin is always taken before the inoculation is made. (The normal thickness of a cow's skin is 6 to 8 millimetres.) Non-tuberculous animals show little increase in the thickness of the skin, and, on palpation, the site of the injection remains hard, cool, and

non-sensitive. In tuberculous animals, palpation of the site shows a varying degree of œdema, the thickness being increased by 10 to 50 millimetres, while local heat and tenderness are manifested. Reacting cattle appear dull and listless, and lose their appetites. The second examination is the more important, and it is found that many animals giving a doubtful reaction to the first dose will be definitely positive after the second. Parker reports that 36 animals were tested by him intradermally and that the results were accurate to the extent of 86·1 per cent. The intradermal test is much easier to carry out than the subcutaneous test, and possesses the advantage that it may be applied as often as required.

As is the case with human beings, cows in an advanced stage of the disease do not always react to the tuberculin test. This is thought to be due to a state of anergy produced by hyper-toxæmia. In addition, the reaction may not occur during the incubation period of the disease.

Tests undertaken by Parker have previously been mentioned. From the results of his observations of tests carried out on animals of all ages, he was of the opinion that the intradermal and ophthalmic tests combined were the most reliable when dealing with cows, but that the subcutaneous test should always be used for the testing of young stock. He published the following conclusions as a result of these experiments :

(1) A positive reaction should be accepted as proof that the animal is tuberculous to *some degree*.

(2) Any reaction, however slight, to the subcutaneous test should be regarded as positive.

(3) The ophthalmic test, although generally regarded as a subsidiary test, may, on occasion, prove the deciding factor when used in conjunction with either of the other two methods.

(4) For testing young cattle (from a few months to two or three years of age) either the intradermal or the subcutaneous tests should be used.

(5) For testing adult dairy cows the intradermal test is more satisfactory.

It should be stated that, as might be expected, the number of cows reacting to the tuberculin test is vastly greater than the number of animals giving tuberculous milk, but the risks of the disease reaching the udder makes it essential that all reactors should be removed from the herd immediately they are discovered.

The double intradermal test, in which two injections, one of avian and the other of bovine tuberculosis are given, is now the approved form of tuberculin test and is used in this country for the purpose of the Milk (Special Designations) Order, 1936. The subcutaneous test has been largely discarded, as any interested party is able to defeat the action of the test by inoculating the animal with tuberculin prior to the official test being made. The possibility of such action on the part of any producer is very remote, but no test should be officially used over which doubts might arise or which would allow of outside interference to the detriment of the consumer.

(2) **Mastitis**

Outbreaks of septic throat in human beings, caused by organisms present in cases of bovine mastitis, have been experienced. The *Streptococcus agalactiæ* in the principal organism concerned in the disease in animals and this is said to be the only organism capable of producing contagious mastitis. Other organisms such as *S. dysgalactiæ*, *S. uberis*, *S. fæcalis*, *E. coli*, *C. pyogenes* and *Staphylococci* have been found in udders affected with the disease, all of which may or may not be dangerous to the consumers of such infected milk. Instances of coliform mastitis are occasionally reported, but their occurrence is comparatively rare. The presence of this type of infection may result in the persistent appearance of coliform organisms in the bulked milk from the whole herd. Mastitis-infected milk is bad flavoured, frequently acid in reaction, has usually a salty taste, and possesses poor keeping quality while often exhibiting a water-like area below the cream-line. From a market point of view, such milk is altogether undesirable. Minett, in a paper read at the International Veterinary Congress in 1931, reported that, in herds examined by him for udder disease in this country, the causative organisms of mastitis were present in 39 per cent. of cows.

Affected animals may be divided into two groups :

(*a*) Clinical cases which are heavily infectious.
(*b*) Latent cases.

The animals generally affected are the heavy milkers, and here again it would appear that super-production is a contributory cause of spread of the disease.

The disease may be further subdivided into four different types as follows :

(*a*) *Simple Mastitis.* This type occurs in all classes of cattle. There is no change in the animal's constitution, and the milk is little altered. The first few " draws " show clots, and very often the milk appears to be unusually thin. It may, however, be thicker owing to the presence of pus, but in such cases it becomes normal again as the milk is withdrawn.

(*b*) *Acute Mastitis.* In this type the udder swells and the infected quarters become tense and painful. There is a sudden decrease in milk flow, accompanied by chills and fever while the cow may show a disinclination to feed. The animal resents milking operations and any handling of the udder. At first the milk shows clots, and later it is of a brownish colour. Finally, pus appears. In acute gangrenous mastitis, the affected teat and quarter assume a purple colour and the secretion rapidly becomes fœtid. The infected tissue may " slough " so that the animal actually loses one or more quarters.

(*c*) *Chronic Mastitis.* It may happen that either the simple or the acute form of the disease becomes prolonged or occurs at intervals, and in this case the disease is known as chronic mastitis.

(*d*) *Latent Mastitis.* This type of the disease does not display any clinical signs, rendering diagnosis of the disease difficult, although there may be considerable infection of the udder.

The disease may either attack the lining membrane of the udder, causing a form of catarrh, or it may attack the tissue itself with consequent pus formation and the loss of the quarter affected. The usual symptoms of *catarrhal mastitis* are slight swelling and redness, with pain in handling the affected quarter, which handling is resented by the animal. Pus occasionally forms, and the tissue of the udder may be attacked. When the udder tissue is affected, there is much pain, considerable swelling, and fever. The animal loses its appetite, and will be thirsty and depressed, while the milk yield is reduced. The loss of a quarter or quarters generally follows such an attack. From an economic point of view, therefore, all available steps should be taken to prevent this disease from attacking the herd.

There are many factors responsible for the spread of mastitis in a herd, and all or any of the following may assist the disease to develop :

(*a*) *Exposure to chills by cold air, water, or wet floors when udder is heated.* This generally leads to the catarrhal type of the disease.

(*b*) *Blows, injuries to the udder, and sores on teat.* A cow with a large udder may receive injury, or damage may be caused by the animal's neighbours stamping on the udder when lying down. Injuries and blows usually cause a deep-seated, severe form of the disease. There is considerable risk of injury to the udder in heavy milking cows.

(*c*) *Negligent milking and want of proper stripping.* Milk which is left in the udder decomposes with a consequent growth of bacteria. A column of milk left in the teat canal favours the entrance of bacteria into the udder, where such organisms come into contact with milk in the improperly emptied cisterns. Milk in the healthy udder never causes inflammation *per se*, any mischief being due to infective organisms reaching the milk cistern. The practice of leaving the teat cups of the milking machine attached for too lengthy periods is a source of irritation which predisposes mastitis. It should always be remembered that only the calf can milk the cow properly.

(*d*) *Irregular milking of the animals.* This may be a contributory cause. As a preventive measure, regular milking is essential, and the milking of heavy-yielding animals should therefore be carried out more than twice daily.

(*e*) *Changing of milkers* This has sometimes a considerable effect upon the animal, which refuses to let down its milk freely for a strange milker.

(*f*) *Dirty hands and dirty floors.* The dirty hands of milkers may spread the disease from animal to animal, while dirty floors on which the animal has to lie favour infection by the causative organism.

(*g*) *Milk fever.* This may cause the disease, particularly when a siphon is used. Siphons should be carefully sterilised before and after use.

(*h*) *Overcrowding of animals.* This may also be a contributory cause of the disease.

The effect on the milk is generally obvious. It may contain blood, be flaky or clotted, or thick, slimy or purulent, while the phosphatase content of the milk is increased. A fall in yield from one or more quarters will be noticeable, and an increase in the alkalinity of the milk will result. This alkalinity can be quickly detected by the producer by means of a "*Dislac*" testing outfit. This consists of an enamelled container which is provided with a cover holding four muslin discs and an indicator of *brom-cresol-purple.* The muslin discs retain any clots present in the milk and, if the liquid is alkaline, the colour changes from yellow to purple. The laboratory chemical tests to indicate the presence of mastitis streptococci in milk are set out on page 374. Difficulty in straining the milk is often the first indication of any abnormality in the udder, while the use of a strip cup (see Fig. 76) which consists of black gauze fitted over a black container, in the case of suspected animals will usually indicate the presence of the disease as clots will be apparent on the gauze. The prevention of the spread of the disease requires care, principally in the direction of cleanliness and proper hygienic measures. The floors should be kept dry for the animal to lie on. The milk from the affected quarter should be milked into a special receptacle, which should be sterilised after use, and the milk should never be allowed to fall on the floor of the standing. The milker should wash his hands in disinfectant after milking the affected quarter. Care should also be taken to ensure that the animal does not require to stand in any draughts. Any animal showing signs of the disease should be removed from the cowshed and isolated until recovery. The curative treatment is, as a rule, elementary.

Sulphanilamide is largely employed to effect a cure, being given either as a drench or, in dealing with certain forms of the disease, the drug is introduced into the blood stream, or the udder. The drenching method has been found to be most effective in dealing with cows which are about to dry off or have dried off, but the method is not infallible. At the moment unfortunately, this drug is in great demand for human purposes and only small quantities are available for veterinary use. One of the simplest remedies is to allow a calf to suck the udder.

Preventive measures for further outbreaks may be summarised as follows:

(*a*) All animals should be properly housed.
(*b*) The cowshed should be disinfected four times per annum.
(*c*) Impervious floors should be provided.
(*d*) Personal cleanliness of milkers should receive careful attention.
(*e*) When teats are washed the water should contain disinfectant, and surplus moisture should be removed with a slightly damp cloth.
(*f*) Teat wounds should receive careful attention, and should always be properly dressed, but milkers themselves should never dress such wounds.
(*g*) Any milk droppings from a suspected quarter should be disinfected and washed away.
(*h*) Newly purchased cows should always be kept separate from the remainder of the herd until the condition of the animals' udders have been noted.

The precautions to be taken in the case of any outbreak of mastitis are:

(*a*) The affected animal or animals should be isolated.
(*b*) Separate attendants must be provided for these animals.
(*c*) Thorough disinfection of that part of the shed which has been occupied by the affected cows must be carried out without delay.
(*d*) The animals affected should be milked after the others into separate pails and the milk destroyed.
(*e*) All sanitary measures must be redoubled.

If any doubt exists as to the existence of mastitis in an animal, producers should always take samples of milk for bacteriological examination. A further precautionary measure consists of periodical examination of all milk for the presence of the causative organisms of mastitis. Some attempts have been made to give protection to cattle by inoculation, but the results obtained vary. Further testing of such methods is essential before their value can be finally determined, and until it is possible to recognise inoculation as a certain preventive measure, cleanliness and hygienic management, together with frequent bacteriological examinations of all milks, remain the best means of defence.

(3) Cowpox

The cause of this disease is a filterable virus which attacks the udder and the teats. Occasionally the animal thus affected is feverish, but such symptoms are often so slight as to escape notice. Normally, the teats and parts of the udder become swollen, the local temperature is raised, while round or oval vesicles filled with lymph appear. These mature, become pitted in the middle, and eventually discharge, when a scab is ultimately formed. These pocks vary in number, and occasionally one forms over the end of the teat canal, from which position it has to be removed. The handling which the udder experiences may prevent the proper development of the pocks, with the result that they are often irregular in shape. A soft scale, which is easily removable, occasionally develops on the external surface of the udder.

The milk does not usually show any particular change in appearance, but it may contain the discharges from the vesicles, which render it unfit for human consumption. The disease affects the animal for a period of approximately three weeks, and the milk should be boiled and given to pigs until the pocks are healed.

Cleanliness is again essential in preventing the spread of this disease, as dirty habits and unsatisfactory cowsheds are the prime causes of dissemination of the infection. The floor of the standing and the bedding should be kept as dry as possible. The udder and teats should also be kept dry with a minimum of handling, and in badly affected cases the milk siphon should be used to assist in this object. Siphon should be efficiently sterilised before and after use. Animals affected should be milked last, and the milker should wash and disinfect his hands after milking. If this is not done, the infection will quickly spread throughout the herd. Infected cows should not be allowed on pastures, and infected bedding should be burnt.

(4) Foot and Mouth Disease

This disease, owing to the infrequent occurrence of outbreaks and the fact that all affected animals, together with contacts, are immediately slaughtered, does not present any serious difficulty from the point of view of milk control in this country. It deserves mention, however, owing to the fact that milk from affected animals may be sold before the disease is recognised, with consequent ill-effects upon the consumer.

As in cowpox, the causal agent of the disease is a filterable virus. The susceptibility of cattle to the virus varies considerably. The incubation period may extend from two to ten days, the affected animals becoming dull, refusing food, and exhibiting an abnormal temperature. Vesicles appear in the mouth, on the pad, lips, and tongue, and also on the feet. The animals make a smacking sound and dribble at the mouth.

It has been proved that the virus can remain active for several months and be carried long distances, these facts explaining outbreaks at points widely separated one from the other. The contents of the vesicles are highly infective. Infection is spread from animal to animal by contiguity in the cowshed and in the pasture, by the hands of the milkers, and even by carriage on the boots and clothing of the attendants. Food-stuffs and water supplies may also act as infective agents. The virus generally enters the body by way of the alimentary tract.

The milk of an animal affected by foot and mouth disease decreases in quantity and becomes bluish in colour and poor in fat. If the udder is badly affected, it becomes yellow, blood-tinged, or dirty. The milk on standing has an offensive odour, and possesses a rancid taste, although there is some evidence to show that the virus is not present in the milk when the udder is free from lesions. The milk may become affected owing to the entrance of lymph from the vesicles.

There are still no apparent means by which the disease may be prevented, as science has not yet discovered any guaranteed means of immunising animals from attack. Any outbreak must be immediately notified to the appropriate authorities and certain preventive measures are necessary, as follows :

(*a*) Affected animals must be isolated from unaffected stock and from public roads, and also from water supplies common to other farms.

(*b*) Attendants on affected animals must not come into contact with unaffected stock.

(*c*) Bedding and other infective material should be burned.

(*d*) The boots of attendants should be disinfected before they leave the vicinity of the affected herd.

(*e*) Milk should not be allowed to leave the infected premises, and should not be given to other animals without being previously boiled.

(*f*) Dogs and poultry in the vicinity should be kept under strict control.

(*g*) After the animals have been slaughtered, the cowshed should be thoroughly disinfected and limewashed.

(5) Actinomycosis and Botriomycosis

Actinomycosis, more familiarly known as " wooden tongue " or " lumpy jaw," is met with in many parts of this country, and cattle are especially liable to be attacked. The disease may extend over a period of months or years, and characteristic tumours, which interfere with the functions of the organs in which they are situated, form in various parts of the body. The causative agent is a parasitic fungus, *Actinomycoses bovis* or *ray fungus*, which grows on grasses and cereals, particularly barley, and flourishes on rich, damp soils. Injuries to the mouth and skin afford the organism an entrance to the tissues. The disease does not appear to spread from animal to animal.

The disease is usually confined to one organ of the body, although it may become generalised. Sores appear on the tongue and lips, and swellings are seen on the jaws, causing extensive enlargement. The animal's throat may also be affected. Pus collects in the cavities formed in the affected tissues. In rare instances, the disease has been found in the udder, where small hard nodules may be detected by palpation, pus being also discharged. These nodules are generally found at the base of the teats.

It is almost impossible to prevent animals being attacked in districts where the *ray fungus* flourishes, as there is no means of eliminating the parasite in infected straw and fodder, short of total destruction. Veterinary treatment can effect a cure, and producers who have animals suffering from the disease should obtain such assistance.

An affection of the udder known as *botriomycosis* resembles actinomycosis, but is rarely seen. When it occurs, the udder tissue is considerably thickened, with the exudation of pus. The udder, when affected with either the latter or the former disease, resembles a tuberculous udder, and veterinary advice is necessary to establish a differential diagnosis. Though the transmission of this disease from one animal to another has not been proved, it is highly advisable for affected animals to be isolated until recovery is complete.

(6) Anthrax

This is a highly contagious infection, caused by the *Bacillus anthracis*, which affects both human beings and cattle. The animal attacked is inclined to separate itself from the rest of the herd. It stands immovable with the head depressed, while in the advanced stages of the disease it declines all food. Rigors or shivering generally occur, the eyes have a fixed staring look, and blood trickles from the nose and will be found in the voided dung. Death follows rapidly on attack. Owing to the malignity of the disease, animals found dead should not be touched until the occurrence has been reported to the appropriate authorities.

The milk from affected animals becomes yellowish in colour and is intermixed with blood. The albumin content is diminished, while sugar and fat are increased. Cessation of secretion quickly follows attack. The organisms can live for at least a fortnight in milk. The remaining animals on premises where a fatal case has occurred often show high temperatures, and it has been suggested that such phenomena are caused by abortive cases of the disease. It is prudent in such cases to reject milk from these animals.

There are no means available of curing the affected animal, but certain precautions are vitally necessary when a case has been notified. They are as follows :

(*a*) The affected animal should not be killed, but carefully isolated.

(*b*) Dead animals should be left alone until seen by a veterinary surgeon, except that external openings should be plugged with some material soaked in disinfectant.

(*c*) Other farm animals should be prevented from obtaining access to the carcase of the animal.

(*d*) All places where the deceased carcase has lain should be thoroughly disinfected.

Preventive inoculation by the Pasteur method has been found to be of value in various parts of the world. Two injections of a prepared vaccine are given at an interval of twelve days. For the first injection an attenuated culture is used, while the second injection consists of a more virulent strain. Cattle inoculated obtain immunity approximately twelve days after the second injection has been given. In the majority of cases the only detrimental result is a temporary indisposition, although occasionally the animal may die. The use of this preventive inoculation is only recommended in cases of fairly heavy annual losses or for animal contacts. Temporary immunity can be conferred on contacts by the injection of a dose of anthrax serum, this constituting a safe and effective means of protection.

(7) **Rabies** (**Lock-Jaw**)

If a cow contracts rabies following the bite of an infected dog, it is possible that the virus of the disease may be secreted in the milk and thus cause human infection, as in foot and mouth disease. Experimentally, milk from an infected source has produced the disease in animals, but no cases of human infection have been reported, although the risk should be borne in mind.

(8) **Contagious Abortion**

The causative organism of this disease, which has been known in this country for a considerable period, is the *Brucella abortus*. Owing to its relationship to Malta fever, this organism is suspected of being the cause of undulant fever in man, but this is a newly discovered danger which, as yet, is imperfectly understood. Large numbers of cattle are affected by the disease and give milk in which the causative organisms are abundant. " Carrier " cows have been discovered in which the organisms are carried in the udder, such animals being infectious to other animals and possibly to man, although themselves displaying no symptoms of the disease. It is becoming apparent from experiments carried out in a number of districts, that a large number of cows may and probably do act in this manner.

In affected animals the flow of milk is seriously interfered with, while discharges from the vulva cause the infection to be spread among the herd. No symptoms follow infection, and the disease may spread through the herd so quickly that the owner is never sure which animal will next " slip " its calf. Some animals may abort within a month of infection, but generally abortion does not occur until three or four months have elapsed. This " slipping " of the calf is often indicated by a preliminary discharge from the genital organs one or two days before such a happening takes place, and this discharge continues for about a month after abortion has occurred. The exudate is at first blood-stained, but soon changes to yellow or dark brown, soiling the tail and the floor behind the animal. The udder, on the approach of abortion, becomes enlarged. The general period for abortion is around the sixth or seventh month of pregnancy.

Affected animals should, if possible, be isolated for a period of three months, and it would also appear advisable to destroy the milk from such animals. Contaminated parts of the body should be washed with disinfectant so long as any exudation is apparent. Germicidal vaginal injections may also be given to affected animals, a mild antiseptic solution (3 per cent. solution of carbolic acid or potassium permanganate 1–1000) being used for this purpose. Feeding- and drinking-troughs should be disinfected and litter should be burnt. The standing and surroundings require thorough disinfection, together with all appliances used for containing milk and for feeding the animal and removing the manure. Infection of the animal in almost every case is due to food contaminated by the causative organism, and many cows become affected through eating grass upon which an affected animal has aborted or has cleansed after abortion. Food-stuffs and water supplies should be protected from contamination by the organisms. Blood tests of the animals should be carried out at periodic intervals, and animals proved positive should be separated from the remainder of the herd.

The disease can be eradicated from herds if the following factors are given requisite attention:

(*a*) All breeding animals should be blood tested.

(*b*) All heifer calves should have been vaccinated by the time they are six months old.

(*c*) All vaccinated animals should be blood tested one month after vaccination. Failure to give a positive reaction demands re-vaccination followed by a further blood test.

(*d*) All vaccinated animals should be suitably marked and records should be kept by each producer.

(*e*) Affected animals should be isolated, with separate pastures, sheds, and attendants.

(*f*) All new animals should be vaccinated and tested before being admitted to the herd.

(*g*) Cows should not be brought in to replenish herds but heifer calves raised instead.

(*h*) Animals should not be exchanged for breeding purposes except between disease-free herds.

Vaccination against infection is now widely advocated and practised, although many producers prefer to obtain what might be termed a natural immunity by allowing the disease to run its course. Vaccination, which should be compulsory, is generally carried out by inoculating the animal with living organisms, after which the number of abortions usually shows a considerable decrease. The Milk (Special Designations) Regulations, 1942 now modifies the Order of 1936 to permit animals in tuberculin-tested herds to be vaccinated with live abortus vaccine subject to the approval of the Minister of Agriculture and Fisheries and with vaccine approved by him. The official vaccine consists of a suspension of living *Brucella abortus* of low disease-producing power. It is produced from *Strain* 19 which resulted through testing the virulence of many strains of *Br. abortus* by Buck whose experiments were commenced in America in 1925. Research workers have proved that with this vaccine:

(1) There is no risk of infection spreading from vaccinated to unvaccinated animals.

(2) Animals in the early stages of pregnancy can be successfully vaccinated without harm.

(3) The vaccine provides good immunity which persists throughout several pregnancies.

(4) Infection does not become localised in the udder.

(5) In the majority of cases the agglutination reaction disappears so that within a few years eradication by blood testing may be possible.

In December, 1944, the Ministry of Agriculture introduced a voluntary anti-abortion scheme for calves. A charge to the producer of 1s. per calf is made and vaccination is carried out by the veterinary inspector making the normal routine inspection of the herd. The fact that this disease causes serious loss to the producer renders it imperative that there should be closer co-operation between the farmer, the veterinary surgeon, and the bacteriologist, than there is at present. More particularly is this the case when the probability of human infection due to the presence of the *Brucella abortus* in milk is remembered.

(9) **Milk Fever**

Milk fever has for long been recognised as a serious disease of cows, especially as it tends to occur when the animal has attained its greatest milking capacity. The latest veterinary researches appear to indicate that the disease is caused by a shortage of calcium in the blood together with an unbalance of other minerals. The disease commences shortly after calving, but may be delayed for a short period. The symptoms are cessation of feeding and rumination, decrease in milk secretion, and rapid breathing, with moaning and dullness of the eyes. The animal finally drops down. As the disease progresses the animal becomes comatose, is unable to swallow or evacuate, and, unless treatment is speedily applied, eventually dies. Animals in a state of collapse should be prevented from lying on their sides as pneumonic complications may result.

Toxins form in the milk during the course of the disease, and, experimentally, milk drawn from the udder of an affected cow and injected into other animals has caused death. The milk, after standing for a period, shows a large amount of fat, but the remainder of the liquid is watery and bluish in colour. Milk from affected animals should not be used for human consumption, but should be destroyed.

The disease may be prevented in the following manner :

(*a*) By reducing the bodily condition of the animal so that it approximates to a normal state. This can be carried out by the use of mild purgatives and by reducing the amount and richness of the food.

(*b*) By turning cows out to grass on a poor pasture shortly before calving. In this way the animal is forced to search for its food, when it will obtain a sufficiency of exercise.

(*c*) By frequent milking after calving.

(*d*) By increasing the amount of calcium in the food. The occurrence of milk fever is said to be favoured by a deficiency of this element.

(*e*) By ensuring that the calf is fed by the cow for a few days after birth.

Treatment by a veterinary surgeon is always necessary, and the injection of antiseptic fluids under strict aseptic conditions which has to some extent replaced mammary inflation with air, is the common mode of treatment.

In America, success has been achieved by the injection of calcium gluconate directly into the veins of the affected animal.

(10) **Digestive Affections**

The digestive affections of an animal have an effect upon the milk secreted. In *tympanites* the excessive gases present may be absorbed into the milk, giving it an offensive odour. In *constipation* and *diseases of the liver* the milk also becomes tainted, while in *diarrhœa* and *gastro-enteritis*, bacteria or their toxins gain access to the milk.

Symptoms of *food poisoning* following the consumption of milk have frequently been reported, chiefly on the Continent, and intestinal disorders in the cow, followed by the entrance of the *Gaertner bacillus* into the milk from Gaertner infection of the animal, are probably the cause. This organism may occasionally be found in the intestines of rats, and rat infestation of premises may pollute food-stuffs, water supplies, and utensils, thus causing infection in the animal and so indirectly affecting the milk. The milk of animals suffering from digestive affections should not be used for human consumption.

(11) Sore Teats

In addition to the diseases already described, teat ulcerations, eruptions, and cuts are frequently found and, although in themselves such affections are harmless, they form a suitable breeding-ground for organisms pathogenic to man. Special precautions are necessary in such cases to ensure that the wounds are kept clean until healed.

(12) Sterility

The presence of sterility in certain animals is often found and may be caused by contagious abortion, bad handling or the employment of infertile bulls. A form of venereal disease in the bull is often the cause of this trouble which may be spread by the use of such animals. Bulls of unknown history should never be bought or used for breeding purposes.

DISINFECTION

Following the removal of diseased animals from the cowshed, it is always essential that their surroundings should be thoroughly disinfected. There are many proprietary articles which can be used for this purpose, while suitably diluted solutions of sulphate of copper or carbolic acid are also useful for walls, floors, and woodwork. Every portion of the walls, floors, feeding-troughs, and gutters adjoining the affected animal's surroundings should be treated, and particular attention should be paid to all angles and crevices if such are present. Following disinfection, the affected portions should be well washed down with hot water and finally sprayed with limewash. Fresh air and sunlight will effectively complete the work.

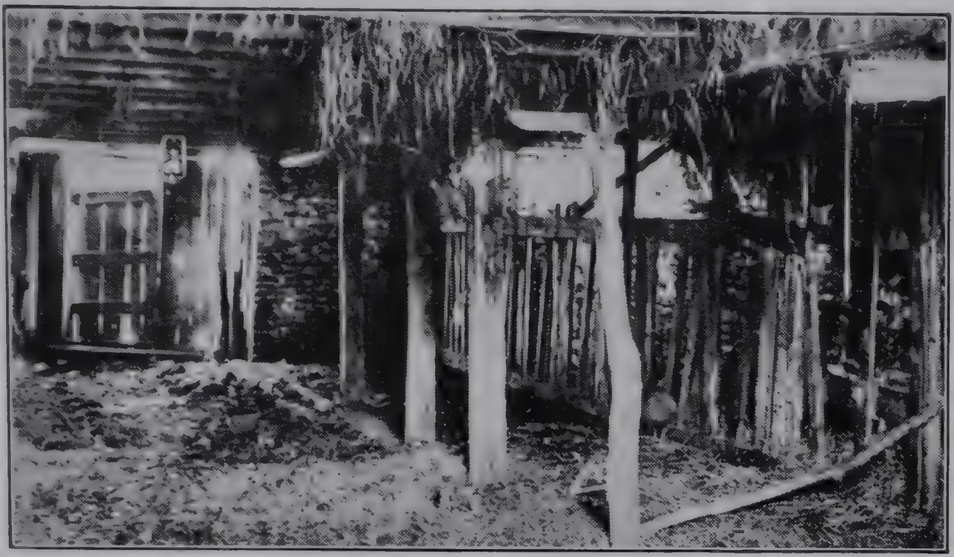
Quite apart from the germicidal action of antiseptics, which varies according to the type used and the purpose to which they are put, the use of such antiseptics is valuable from the standpoint of impressing the workers with the fact that potentially dangerous, infective factors are present. It should never be forgotten, however, that antiseptics can never take the place of cleanliness, and that soap and water in abundance will accomplish much at little cost.

CHAPTER IV

THE COWSHED

INTRODUCTORY

THE cowshed or cow-byre is the home of the cow for a considerable portion of the year, this portion varying with the district in which the animal has its habitation. The inclement weather experienced in a large proportion of these islands renders it imperative for the animals, in many cases, to spend the entire winter in the cowshed. The fact that the animal has to live, eat, sleep, and perform its natural functions in the cowshed, in addition to its having to be milked in the same place during the winter months, makes it necessary for the owner to give considerable attention to the structural condition of the buildings in which the animals are housed. More particularly is this the case when it is remembered that the aim of all producers should be to produce clean milk free from pathogenic bacteria.



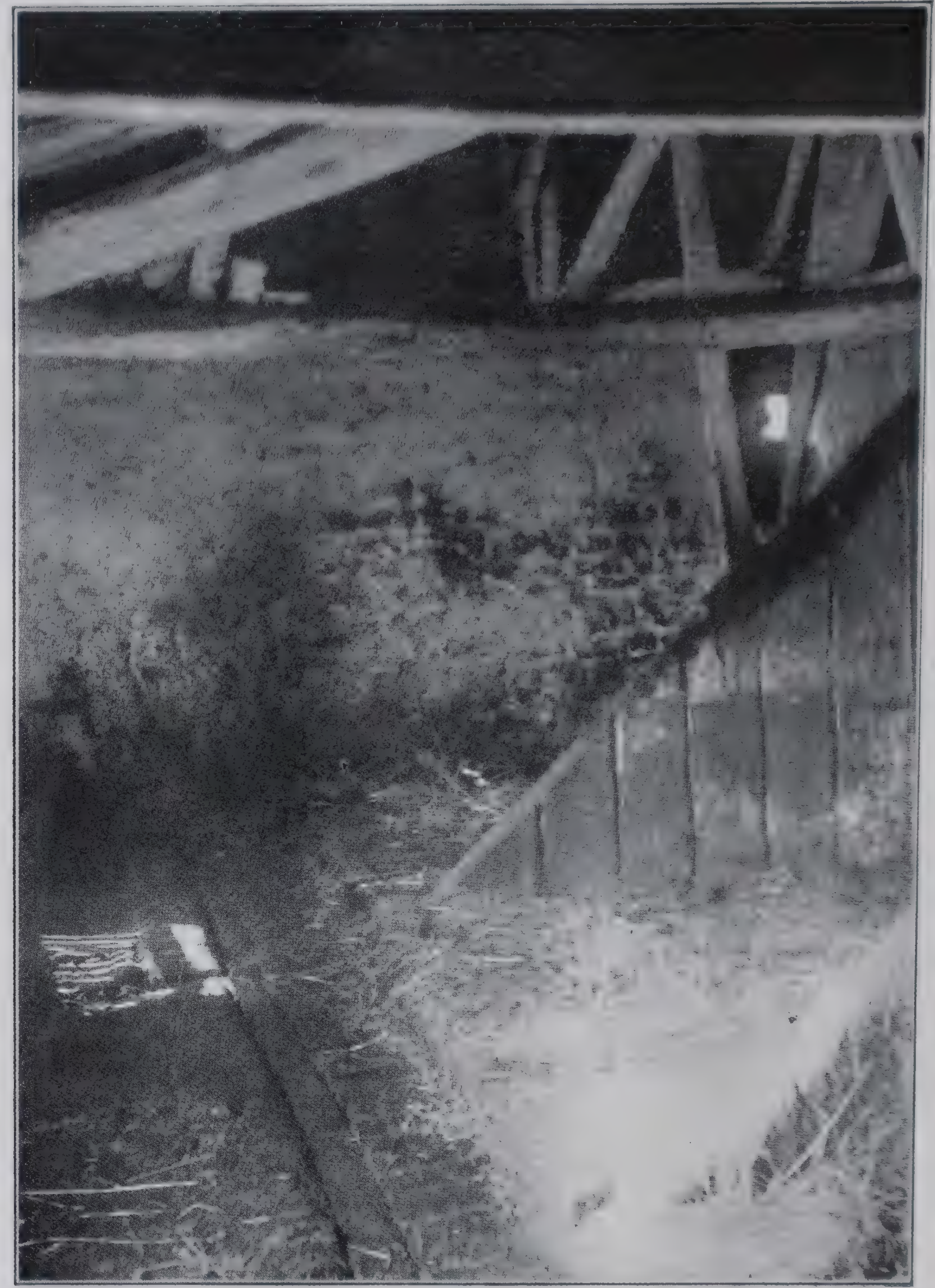
By courtesy of the United Dairies Ltd.

FIG. 4. Unsatisfactory Cowshed with Filthy Interior.

The facts set out above are such obvious truisms that one would expect them to present little if anything in the way of problems. Such, however, is very far from being the case.

Much attention has been paid, and still continues to be paid, to the housing of the population of this country with a view to reducing the incidence of disease, by providing a sanitary environment in which the worker may enjoy his leisure and rear his family under reasonable conditions. Unfortunately, such attention has not been paid to cowsheds, although these are surely of sufficient importance to deserve more than casual attention, particularly when one realises the vital part which they play in the production of one of our most valuable foods and the increasing attention being paid to the health of dairy herds. Although there are many cowsheds in this country at the present time which are of the most hygienic design and construction, it is to be regretted that there are also many more whose construction leaves a great deal to be desired. Nowhere are these faults more obvious than in our rural areas, where, be it remembered, the bulk of the country's milk supply is produced.

It is no exaggeration to say that the majority of the cowsheds in this country are still relics of a period when hygiene on the farm was non-existent, and when labour was so poorly paid that it was not considered worth while to arrange for its proper utilisation. These cowsheds are anything but ideal; their cleansing is difficult to accomplish properly; drainage is often non-existent, and lighting and ventilation are in direct contradiction to accepted hygienic principles. Yet, in many instances, the farmer wonders



By courtesy of the Newburn U.D.C.

FIG. 5. An Unsatisfactory Cowshed. (Note dark interior).

why it is impossible to maintain a healthy herd in buildings of the type illustrated. Figs. 4 and 5 show that the day of the dark, ill-ventilated, insanitary cowshed has not yet vanished. Any person with an elementary knowledge of infection and contagion will realise at once that the health of the animals must suffer in such an environment. It is in such premises that the animals are often herded together for a large portion of the year,

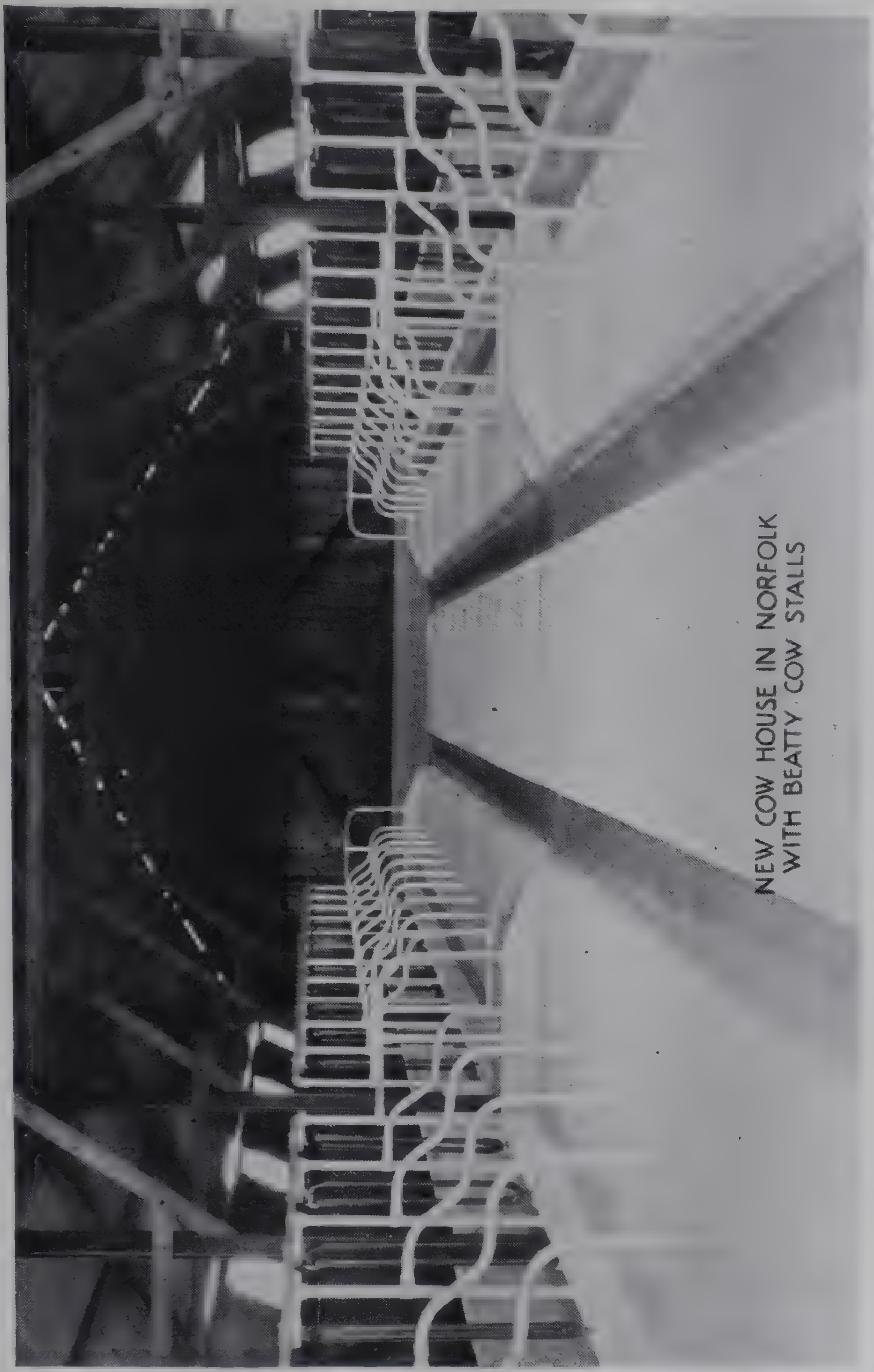


Fig. 6.

By courtesy of Beatty Bros., Ltd.

breathing a fœtid atmosphere, eating with other animals from a joint manger, and drinking from a common trough. Under such conditions it would be impossible to expect human beings to escape infection from tuberculosis and other diseases. Is it therefore to be wondered that animals infect each other when housed in this way, and that tuberculosis is so prevalent in dairy herds? Compare these old buildings with the modern cowsheds illustrated in Figs. 6 and 7, and the difference in conditions will be readily appreciated.

The cause of the existence at the present time of such buildings may be ascribed to neglect of the proper use of the advice and control which could and should be applied under the powers provided by the Milk and Dairies Order. These powers are provided for definite use, and although perhaps certainly not so adequate as might be desired, they are nevertheless sufficient to effect an improvement. Such buildings should be taken in hand and either reconstructed, or, if this is impossible or undesirable, demolished, and new buildings erected in their place. In either case, expense or outlay is unavoidable, and, if the necessary funds are not otherwise available, loans to producers, granted by the State at a low rate of interest, might meet the case. Actually, long-term loans would solve, not only this problem, but others equally clamant. It would provide work in our rural areas, encourage industry, give the producer an up-to-date building in which it would be a pleasure to work, lower the incidence of disease among dairy cattle, and finally, if proper methods were used, result in the production of clean milk.

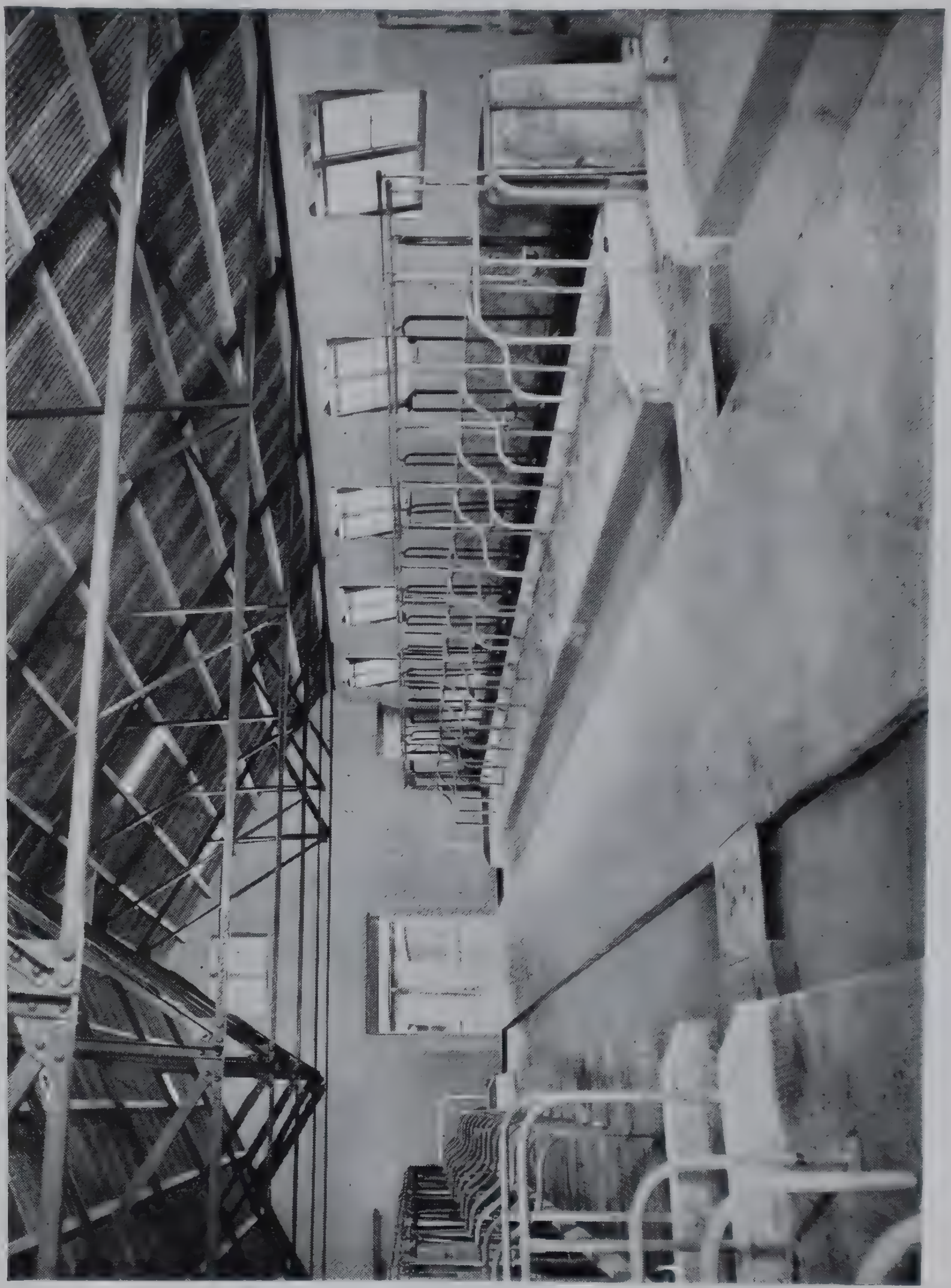


Fig. 7. Modern Cowhouse. (Note windows, roof lights and gable window).

By courtesy of the Cement and Concrete Association.

One of the chief requirements for the production of milk for human consumption is cleanliness, and although it has been proved that clean milk can, by the use of careful methods, be produced in an unsatisfactory cowshed there is no doubt that a good, hygienically planned and equipped building is an invaluable asset to the farmer, and is of very great assistance in any efforts he may be making towards the production of a clean article. It is also of great assistance to those who are engaged in encouraging the farmer to improve the public milk supply. Farmers are only human, and what person would not be discouraged by having to struggle to produce clean milk in buildings such as those shown in the first two illustrations? The labour required in the production of milk in buildings of that type is enormous, and as the economics of farming render it essential that labour should be saved wherever possible, a properly planned and constructed building is virtually a *sine qua non*.

PLANNING AND ERECTION OF COWSHEDS

Before dealing with the essentials necessary to the planning and erection of a cowshed, it should first be mentioned that three general *methods of cow-keeping* are to be found in this country. Several modifications are also in existence, but they vary only in minor detail. These methods are as follows:

(1) In which the animals spend the summer months in the open fields, coming into the cowshed only for the purpose of being milked, but being confined to the building from the end of September or beginning of October until April.

(2) In which the procedure is similar to that outlined above, except that the cows are allowed out in the day-time during the winter months for varying periods, weather permitting.

(3) In which a milking shed is in use, the cows being kept out in the fields during the summer, and living in a covered strawyard with open sides during the winter. Milking is carried out during both summer and winter in the milking shed. This method is impracticable in districts which experience severe winter weather.

Several fundamental factors have to be considered in designing and erecting a cowshed. These are:

(1) Site and Aspect.
(2) Size and Planning.
(3) Cubic Space and Ventilation.
(4) Lighting.
(5) Construction and Fittings.
(6) Water Supply and Drainage.

(1) SITE AND ASPECT

Cowsheds, being expensive to erect, should not be built without great care being taken with reference to their *sites*. If the site is not carefully considered and building begun in a haphazard manner, it is quite possible that considerable expense may be incurred after the building has been erected, which expenditure might well have been avoided by a little preliminary thought. Generally speaking, it may be stated that the conditions appertaining to an ideal site for a dwelling-house hold in the case of cowsheds, viz.,

(*a*) Suitable subsoil.
(*b*) Absence of ground water near surface.
(*c*) Abundant water supply in the vicinity.

The buildings used in conjunction with the cowshed, i.e. the dairy and its washing or sterilising room, the food-store and the milking shed, if one is provided, should be adjacent to or part of the same building as the cowshed, as a means of labour-saving and with a view to economical working. These matters should always be considered before a site is chosen, to ensure that sufficient space is available for their erection. The possibility of future extension to the buildings must also be considered. The site chosen should, if possible, be on high, dry ground to facilitate drainage and also to prevent surface water obtaining access to the building. Preference should be given to land having a slight fall on all sides.

Care should be taken to erect the building near an existing road to avoid later road-making charges, and the site should make allowance for easy access of the animals to the pastures. If possible, a site should be selected on the leeside of a windbreak of trees or other buildings, as shelter from cold winds and gales is desirable. The site should not be too near trees and other buildings, since too close proximity would tend to obstruct light and ventilation. An abundant, pure water supply is definitely essential, both for the health of the animals and as an aid to clean milk production. If water cannot be laid on, a sufficient supply should be available adjacent to, or of easy access from the site, so that it can be used by the animals passing to or from the pastures.

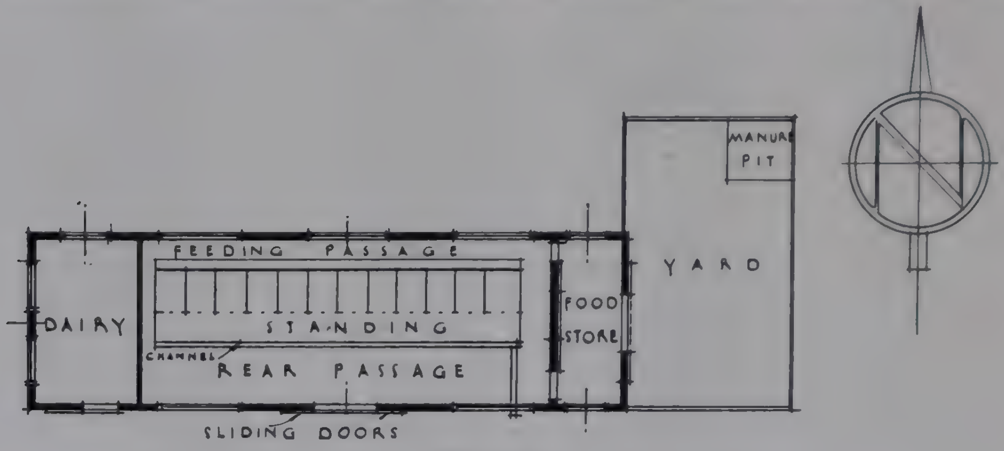

MANURE PIT
FEEDING PASSAGE
YARD
DAIRY
STANDING
FOOD STORE
CHANNEL
REAR PASSAGE
SLIDING DOORS

FIG. 8.

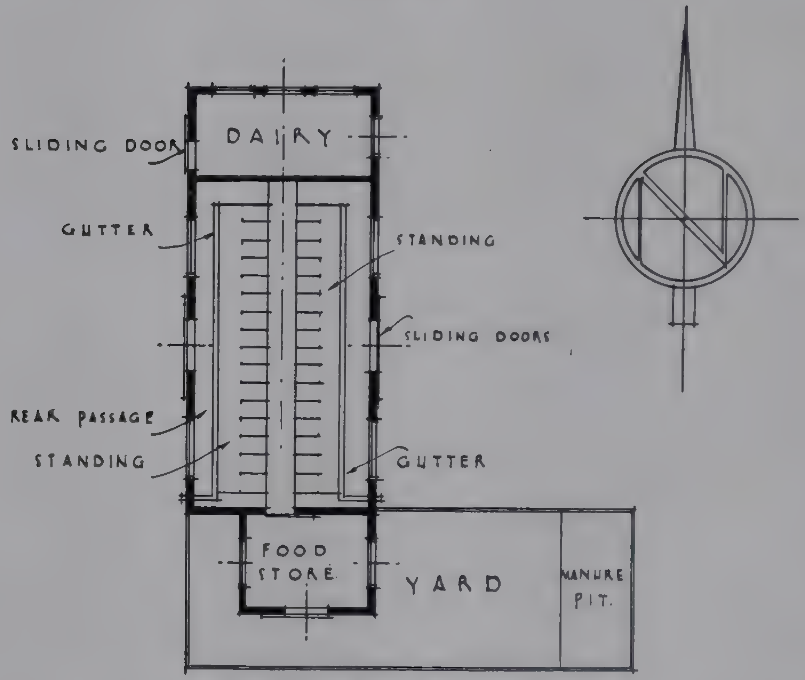

SLIDING DOOR
DAIRY
GUTTER
STANDING
SLIDING DOORS
REAR PASSAGE
STANDING
GUTTER
FOOD STORE
YARD
MANURE PIT.

FIG. 9.

The *aspect* of the building should always be considered in conjunction with the site. As good natural lighting is essential, this consideration is important. Broadly speaking, double-range cowsheds should run in a northerly to southerly direction (Fig. 9), but, if desired, single-range sheds (Fig. 8) may run from east to west, provided shelter is to be found on the northern side. The placing of a shed in a north-south direction ensures that it will obtain not only the early morning and later afternoon sun, but also, that it will secure a maximum of sunlight per day, an invaluable adjunct to animal life. If the shed is placed in this position, the cold northerly winds tend to strike on one end of the building, thus minimising loss of heat by protecting the greater portion of the building from the full force of the elements. The northern end could be further protected by placing the dairy there, in what would thus be the *coolest* position and one which affords northerly light to the milk room. The food-store, yard, and manure pit could then be placed at the southern end. Figs. 8 and 9 show, respectively, single- and double-range sheds placed in the positions outlined above.

Whichever aspect is chosen, it should be remembered that the chief desideratum is abundant natural light, both in early morning and late afternoon, as well as during the middle of the day. As adequate artificial light is not always available, especially in rural areas, the choice of aspect with relation to natural light becomes doubly important.

(2) SIZE AND PLANNING

Following the selection of a suitable site, the size and type of shed required should be considered. The *size* of the cowhouse naturally depends upon the number of animals to be accommodated, and also upon the breed of cow, which will inhabit the building. The size of the cattle stands has a bearing on the floor space to be provided, and below are given maximum measurements for cattle stands for the chief breeds of dairy cattle :

Breed.	Maximum length of stand per cow	Maximum width of stand per cow.
	Feet.	Feet.
Friesian	5¼	3½
Shorthorn	5¼	3½
Devon	5¼	3½
Ayrshire	5	3¼
Guernsey	4¾	3¼
Jersey	4¾	3¼

It should be remembered that these are maximum measurements. The length of the stand may be decreased by approximately 6 to 8 inches if tubular yokes are used, as in such a case the cows are kept well forward from the gutters, while both the length and width of the standing may have to be decreased slightly, according to the average size of the animals in the herd irrespective of breed.

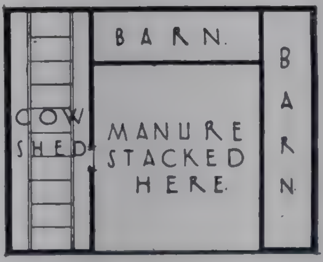


Fig. 10.

The plan found in most existing farms is illustrated in Fig. 10. It will be seen that the buildings form the boundaries of a square surrounding the yard, where manure is kept to mature. The entrance to the cowshed is commonly reached through the yard, which means that, to enter the cowshed, the cows have to pass through what is often in wet weather a quagmire of manure, the milk having also to be removed by the same route. This is totally wrong, and in planning cowhouses care should be taken to ensure that the entrance for the animals is dry and clean, and that the milk can be removed without undue risk of contamination. *Two cardinal assets in the construction of any cowshed are clean air and clean surroundings.* Manure should never be placed adjacent to the cowshed as it gives off offensive odours which can taint the milk supply, besides providing an excellent breeding-ground for flies. Dust and flies are two prime factors in the spread of disease, and a cowshed should be so planned as to afford maximum freedom from these nuisances.

Labour-saving means economical working, and much unnecessary expenditure may be saved by efficient planning. Single-row cowsheds are quite satisfactory where not more than 10 to 14 cows are kept, but when it is necessary to house a larger herd than this number, the best plan is to arrange the animals in two rows. By this means much time and labour are saved in feeding, milking, and cleaning the animals.

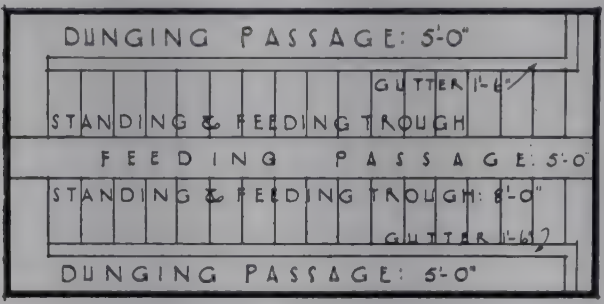


FIG. 11.

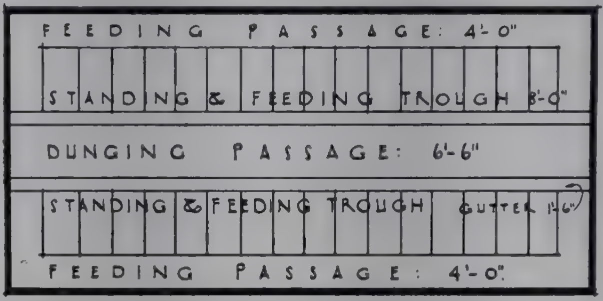


FIG. 12.

The economic superiority of double-range cowsheds over single-range sheds can easily be demonstrated. The case of a farmer who has to house a herd of 32 Dairy Shorthorns may be instanced. With a single-range cowshed a building 134 feet by 18 feet would be required. If a double-range shed were erected to hold a similar number of cows, the building would have to be 72 feet by 32 feet (these sizes allow for the necessary feeding and milking passages). The single-range building would thus require 108 square feet more superficial area of floor space, while the cost of the roof span, floor area, foundations, and wall would be materially increased. Taking the height of the 9-inch brick walls as 8 feet, 576 cubic feet more material would be required when building the single-range type of cowhouse. This large increase in the cost of materials is economically unsound.

The essentials of a well-planned cowshed may be stated as follows:

(1) The construction should be sound, and the building arranged to provide easy working for the men and comfort for the animals.
(2) The cows should be enabled to keep themselves as clean as possible.
(3) The labour of feeding, watering, and cleaning the animals should be capable of being reduced to a minimum.
(4) The food storage should be so arranged that it is convenient for the feeding passages.
(5) The lighting and ventilation should be adequate.
(6) The premises should permit of easy cleansing.
(7) Ample water supply for drinking and washing purposes should be provided.

In double-range cowsheds the animals may either be arranged head to head or tail to tail. Figs. 11 and 12 illustrate the differences which exist between the two systems. As will be seen, the width of the head to head shed is slightly more than is the case where the cows are arranged tail to tail.

There has been much controversy as to whether the head to head or the tail to tail method of arranging the animals is the better. Put briefly the various arguments for and against each system are as follows :

(1) Head to Head Method.

Advantages Claimed :

(*a*) Light is on the hindquarters of the cow, the greater part of the work is done in good light, and the milker can see if the udders are clean.
(*b*) Feeding is easier, as the animals can be fed on both sides of the central feeding passage at one time.
(*c*) The animals do not face the light.

Disadvantages Claimed :

(*a*) Extra work in removing the manure is entailed.
(*b*) The animals breathe into each other's faces. (*Note.* If the central passage is made slightly wider than normal, say 5 feet instead of 4 feet, and the ventilation outlet is in the ridge directly overhead, this so-called disadvantage does not assume such serious proportions.)
(*c*) Manure from the gutter spatters the walls.
(*d*) The herd has to be divided when tying up the cows.

(2) Tail to Tail Method.

Advantages Claimed :

(*a*) The cleaning and milking are centralised.
(*b*) There is no danger of cows breathing on one another.
(*c*) The manure does not spatter the walls.
(*d*) The herd does not have to be divided.

Disadvantages Claimed :

(*a*) Extra work in feeding is entailed.
(*b*) The light for milking and cleaning is in the wrong position. (*Note.* This argument loses its force when windows are put in the gable and roof lights are provided.)
(*c*) The heads of the animals are close to the draught from the windows.

From the foregoing it will be seen that the advantages and disadvantages of each system appear to be nicely balanced and tend to cancel out. Under the circumstances, the choice may safely be allowed to rest with the particular views of the owner.

Types of Layout

This is a simple matter when dealing with new buildings, as it is merely a question of considering the number of animals to be housed and the ideas of the owner as to feeding passages, head to head or tail to tail ranges, etc.

Three alternative types are illustrated in Figs. 13, 14, and 15.

Type 1. Single range—accommodation for 10 cows with or without feeding passage, as desired.

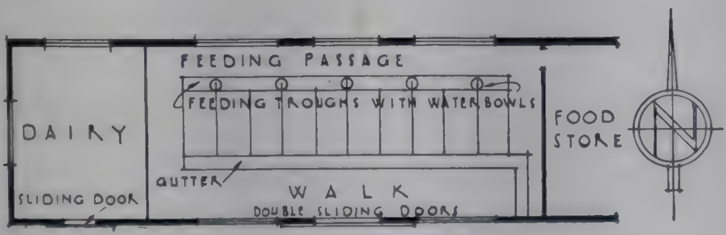


FIG. 13.

Type 2. Double range—head to head—accommodation for 32 cows.

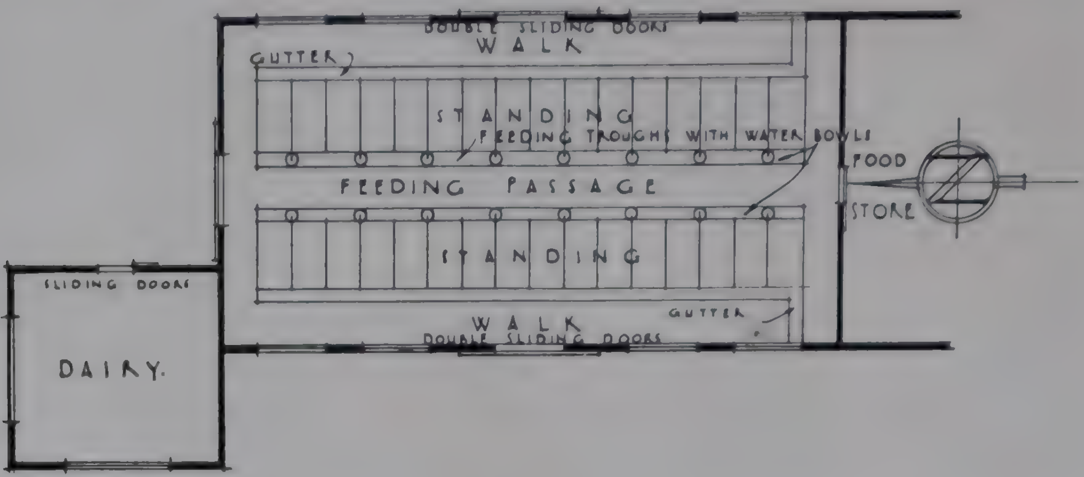

DOUBLE SLIDING DOORS
WALK
GUTTER
STANDING
FEEDING TROUGHS WITH WATER BOWLS
FOOD STORE
FEEDING PASSAGE
STANDING
WALK
GUTTER
DOUBLE SLIDING DOORS
SLIDING DOORS
DAIRY.

FIG. 14.

Type 3. Double range—tail to tail—accommodation for 32 cows with or without feeding passage, as desired.

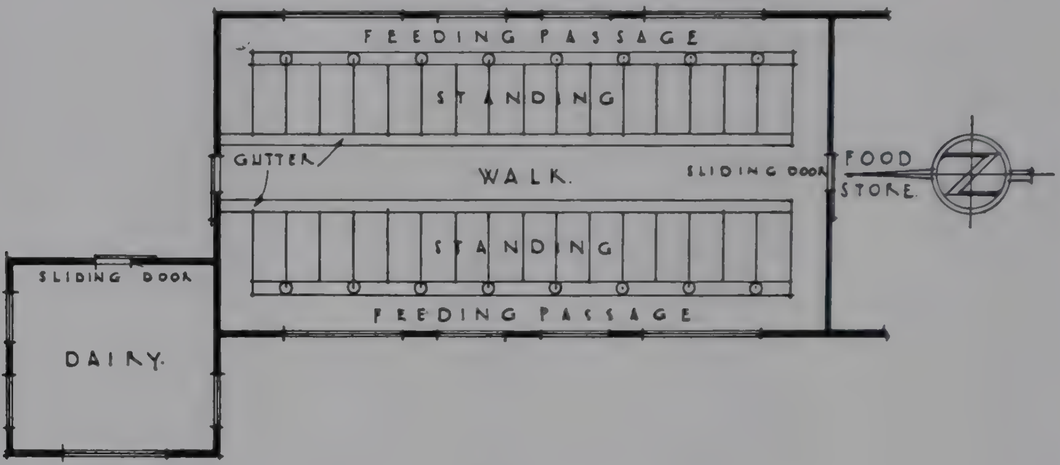

FEEDING PASSAGE
STANDING
GUTTER
WALK.
SLIDING DOOR
FOOD STORE.
STANDING
FEEDING PASSAGE
SLIDING DOOR
DAIRY.

FIG. 15.

The three types illustrated can be accepted as standard, but it should be emphasised that these layouts must not be taken as absolutely fixed designs. They may be varied to suit individual requirements, since it is impossible to lay down a definite plan which will suit all local circumstances. As an instance, a farmer may have to build without any provision for feeding passages because of difficulties regarding site. It is usually quite possible to alter the layout as regards detail without interfering with the general design and also without destroying either the farmer's chance of working economically or of producing clean milk.

Cattle Standings

The provision of good standings is most important as an aid to cleanliness and for the comfort of the animals. The standing should be long enough to accommodate the cows comfortably, but should be sufficiently short to ensure that the dung falls into the gutters. If the standings are too short, the cow will stand with its hind legs in the gutter, and this will eventually cause diseased feet ; while a standing which is too long allows the animal to drop its dung on the floor instead of into the gutter. The animals when at rest will then lie in this voided dung, and will so soil their hindquarters and udders that it will be a difficult and troublesome matter to keep them reasonably clean. The stalls must be wide enough to prevent the animals standing on each other's legs, udders, or teats, more especially as injury to the udder generally means the loss of a quarter. If, on the other hand, the standings are too wide, the cows can turn round and drop urine or excrement on the floor of the stall. This can be prevented by a separate division being provided between each beast, and this should be done whenever possible. Earlier in this chapter figures were given showing the approximate length and width of standings for the different breeds of cattle usually kept. It is, however, advisable when planning the standings for a cowshed in which different breeds and sizes of cattle are to be stalled, to make the standings at one end slightly larger than those at the opposite end, the length gradually decreasing from one end to the other. In this way it is possible to provide comfortable stalls for the different types of animal, with great advantage both to the beast and its owner.

Figs. 16–19 show sections of various types of standings, gutters, etc., with the maximum sizes in different types of cowshed.

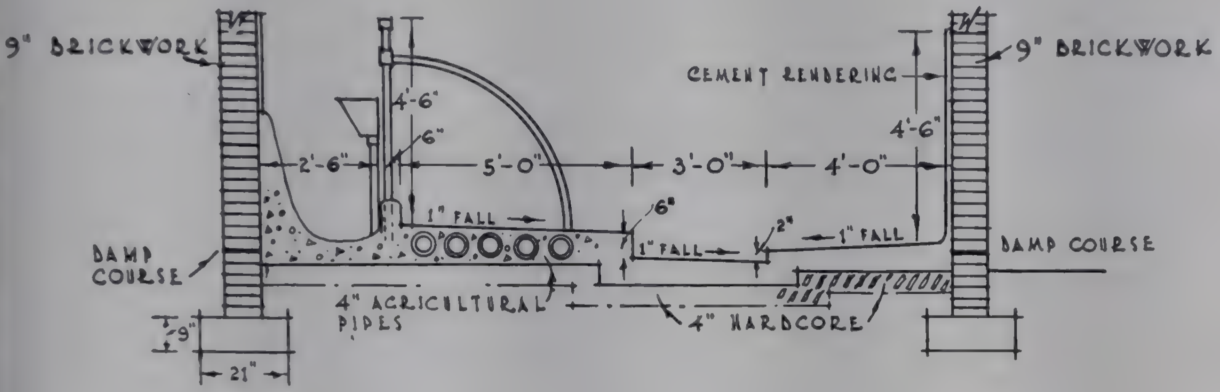


FIG. 16. Single-range Cowshed without Feeding Passage.

Passages

For the purposes of feeding and milking and for the removal of manure, passages are necessary. Feeding passages should not be more than 3 feet in width. This permits of the use of a barrow or hand truck when feeding the animals but prevents such passages being used for the storage of food. In a double-range cowshed, where a central passage is used for feeding, this should not be more than 4 feet in width. The feeding passages should provide easy access to and from the food-store. Milking and dunging passages in single-range cowsheds should be at least 4 feet in width, while in double-range cowhouses the width should be at least 6 feet where the cows are stalled tail to tail, and 4 feet where the animals stand head to head. In large cowhouses it is advisable that the centre passage should be sufficiently wide to enable a cart to be drawn through when cleaning out, while a connecting passage should be provided at each end of the standings. Centre feeding passages should have a fall of ½ inch each way from the centre to the feeding troughs. When feeding passages adjoin the wall, they should have a fall of 1 inch to the feeding-trough. The centre dunging passage should fall ½ inch in each direction to the gutter. When the animals face inwards and the dunging passages adjoin the walls, the fall should be 1 inch from the wall to the gutter.

Pens

One or two *calving pens* should be provided, preferably in the main building, and also *sick pens*, which should be easily accessible under cover from the cowshed. Calving and sick pens should have a minimum area of

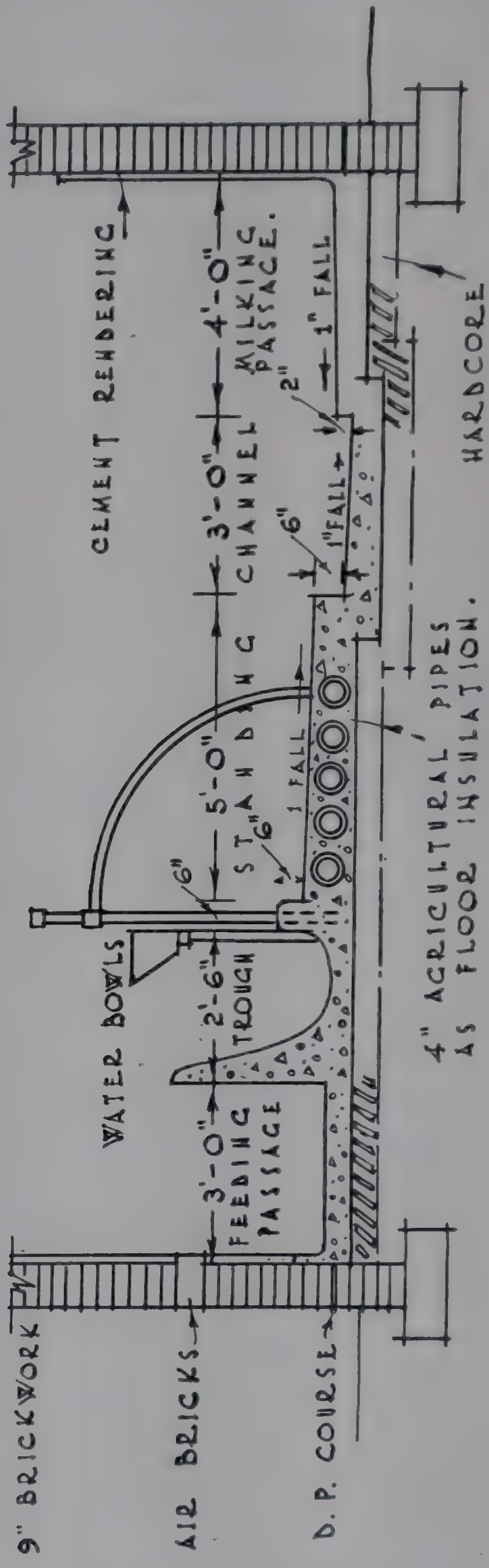

9" BRICKWORK
AIR BRICKS
D. P. COURSE
WATER BOWLS
CEMENT RENDERING
3'-0" FEEDING PASSAGE
2'-6" TROUGH
6"
5'-0" STANDING
6"
1 FALL
3'-0" CHANNEL
6"
1" FALL
4'-0" MILKING PASSAGE.
2"
1" FALL
4" AGRICULTURAL PIPES AS FLOOR INSULATION.
HARDCORE

Fig. 17. Single-range Cowshed with Feeding Passage.

100 square feet. They should be warm, adequately lighted, and well ventilated.

Food-store

In designing a new cowshed it is advisable to provide a food-store and mixing room under the same roof, but preferably divided from the cowshed. It should be of easy access from the feeding passages and, if a silo is in use, the chute should be brought direct on to the mixing floor. A wide door capable of allowing a cart to enter should also be provided. Provision should be made for storage according to the size of the herd and for accommodation of machinery.

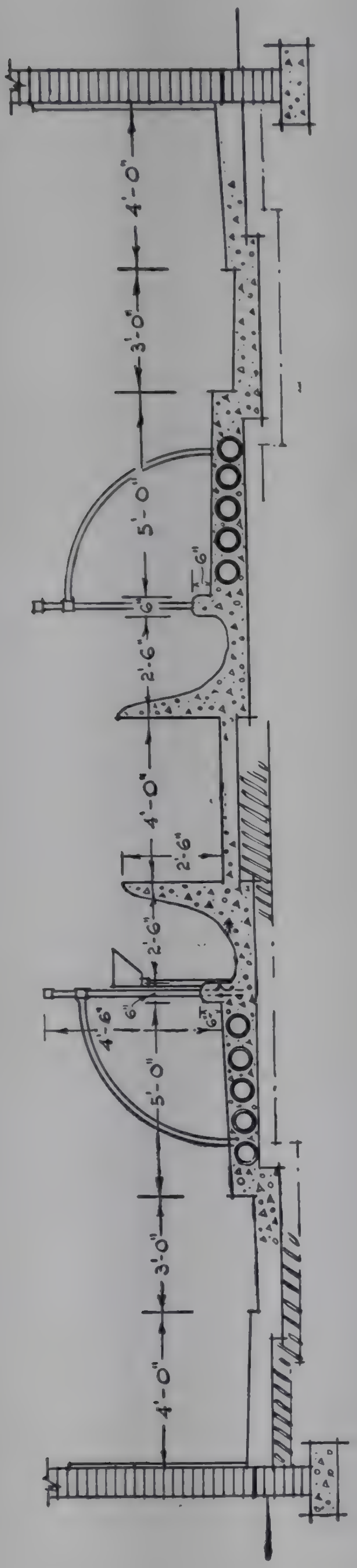

4'-0"
3'-0"
5'-0"
6"
6"
2'-6"
4'-0"
2'-6"
2'-6"
6"
4'-6"
6"
5'-0"
3'-0"
4'-0"

FIG. 18. Double-range Cowshed with Central Feeding Passage.

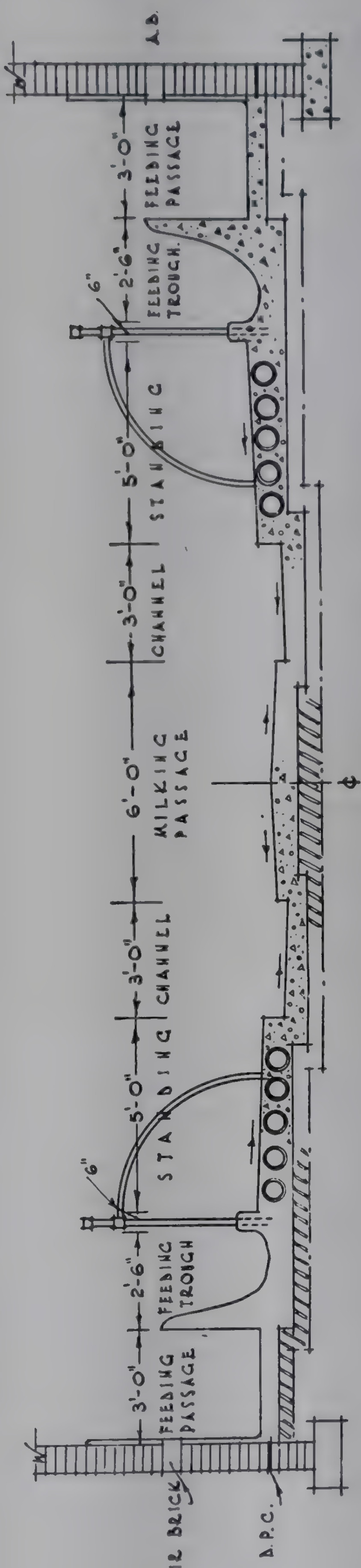

A.B.
3'-0"
FEEDING PASSAGE
2'-6"
FEEDING TROUGH
6"
5'-0"
STANDING
3'-0"
CHANNEL
6'-0"
MILKING PASSAGE
3'-0"
CHANNEL
5'-0"
STANDING
6"
2'-6"
FEEDING TROUGH
3'-0"
FEEDING PASSAGE
AIR BRICK
D.P.C.

FIG. 19. Double-range Cowshed with Central Milking Passage.

(3) CUBIC SPACE AND VENTILATION

The *cubic air space* required for each animal varies according to the breed to be housed. For adult cows of large breed, such as Shorthorns, 700 to 800 cubic feet are necessary, particularly when the breeds are stalled all day during the winter. For smaller breeds, such as Jerseys, 600 to 700 cubic feet would be sufficient, provided the cowshed was used entirely for the housing of this or similar breeds. In the calculation of cubic space it is necessary to omit any height above 14 feet from ground-level from consideration, as any extra height above this figure is of little use for ventilation purposes. This fact renders it essential that the maximum amount of floor space possible should be provided.

The suitability or unsuitability of a cowshed has often been judged from a sanitary point of view by the amount of cubic space per head provided, the assumption being that, where a large cubic space per head is allowed, the air in the building remains pure for a longer period. In the case of buildings in which the cattle are stalled for the winter months, this reasoning is fallacious, although when buildings are occupied for short periods it may be quite correct. It is not possible, whatever the cubic space provided, to ventilate a cowshed in which the animals are constantly stalled, by natural means only. Consequently, the air becomes rapidly impure unless provision is made for adequate ventilation.

In designing a cowshed it is therefore of enormous importance to provide the building with an efficient system of *ventilation.* Good ventilation is only obtained when fresh air is admitted and foul air escapes with sufficient regularity and in sufficient volume to allow the atmosphere of the cowshed to remain pure and wholesome on *all* occasions. As ventilation has a direct influence upon the health of the animals, and as their ill-health has a marked effect upon the quality of the milk, it will be understood that this subject should receive very careful attention. There can be no doubt that cows suffer from excessive cold, nor that draughts cause a definite decrease in the yield of milk. It is this knowledge which in the past has caused and still causes some farmers to assume that the warmer they make the cowshed the higher will be the yield of milk. To attain this warmth they block up all ventilators with straw, and hermetically seal all windows during cold weather. Indeed, they have even been known to go to the length of preventing the entrance of air under the cowshed doors by means of old sacking! This, as might be expected, results in stuffy, oppressive cowsheds, especially in the early morning.

A dark, stuffy cowshed is an abomination. It forms an ideal breeding-ground for disease and ill-health ; lowers the stamina of the animals through the constant inhalation of vitiated air containing excess of water vapour and organic products of respiration, and has, in addition, obvious repercussions upon the health of the workers. This should not be tolerated. Windows are provided for use and not for ornament, and should be opened within the wide limits allowed by the climatic conditions. Trouble experienced with the herd in the way of decreased yield is never due to a combination of adequate ventilation and low temperatures, but is a definite proof that draughts and excessive cold are reaching the animals, a very different matter. Actually, as we have seen, the presence of such draughts is a clear indication that the shed is badly ventilated, for draughts are never present when an efficient ventilation system is in use.

It is interesting to recall that the Highland and Agricultural Society, as far back as the winter of 1908–9, carried out some interesting experiments dealing with the question of ventilation and milk yield. These experiments showed :

(1) That there was no substantial gain in the purity of the air in buildings with a large cubic air space per cow when compared with buildings of moderate size..

(2) That the air of any cowhouse, whatever the cubic space per cow allowed, if kept at a temperature of 60° F. or more, contains three times the quantity of carbon dioxide than if the building were freely ventilated, with the temperature kept at approximately 50° F.

(3) That there was no decrease in the milk-yield at the lower temperature.

(4) That the health of the animals was improved at the lower temperature, and that they were less subject to chills.

The conclusions reached show a complete reversal of the previous idea that overheated cowsheds, achieved mainly by want of sufficient ventilation, were necessary for the housing of cattle, yet, nearly forty years later, the ancient superstition still persists !

As already stated, adequate ventilation aims at frequently replacing the atmosphere of the cowshed with fresh air without creating draughts or unduly lowering the general temperature. The air exhaled by the beasts is higher in temperature than that inhaled, and consequently the general temperature of the shed gradually rises during occupation. As warmed air is lighter than cool air, it tends to rise, and collects at the highest point of the roof. For this reason the ideal system of outlet ventilation is the *ridge* system, which is deservedly popular and should always be used in new buildings. Figs. 20–24 show various types of such outlets.

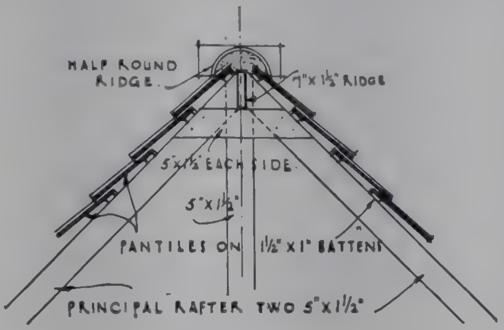

HALF ROUND RIDGE.
7" x 1½" RIDGE
5" x 1½" EACH SIDE.
5" x 1½"
PANTILES ON 1½" x 1" BATTENS
PRINCIPAL RAFTER TWO 5" x 1½"

FIG. 20.

In Fig. 20 every sixth ridge tile is turned at right angles to the ridge for ventilation purposes. This system is only to be recommended in small cowhouses or for reconstruction work where expense is a consideration.

The perforated ceiling above the skylight shown in Fig. 21 exerts a con-

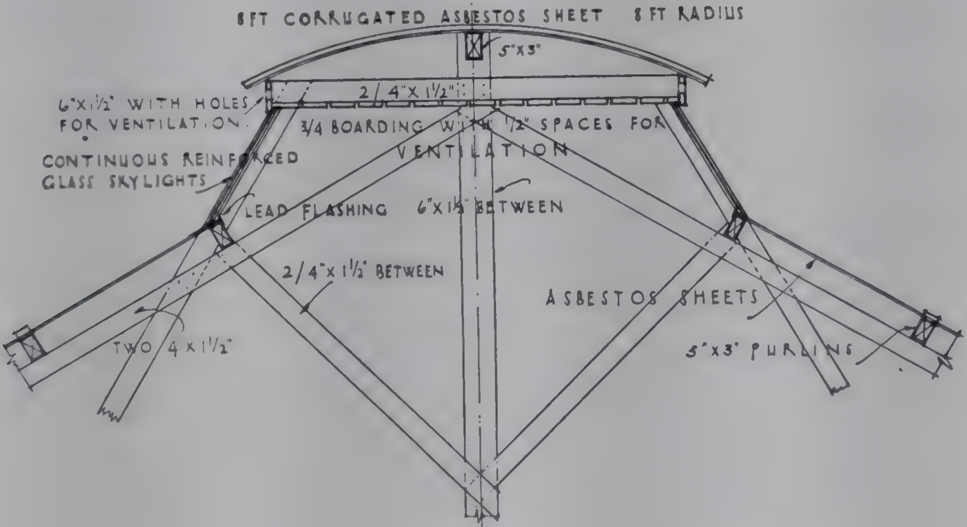

8 FT CORRUGATED ASBESTOS SHEET 8 FT RADIUS
5" x 3"
2/4" x 1½"
6" x ½" WITH HOLES FOR VENTILATION.
¾ BOARDING WITH ½" SPACES FOR VENTILATION
CONTINUOUS REINFORCED GLASS SKYLIGHTS
LEAD FLASHING
6" x 1½" BETWEEN
2/4" x 1½" BETWEEN
ASBESTOS SHEETS
TWO 4 x 1½"
5" x 3" PURLINS

FIG. 21.

siderable suction through the spaces, and causes free circulation of the air in the cowhouse.

Opening roof lights (controlled from floor-level) are provided in the type of ventilator illustrated in Fig. 22.

In Fig. 23 the desired number of ridge tiles are raised, leaving openings. The tiles are superimposed and bedded in cement. This system is suitable for small cowsheds and inexpensive reconstruction schemes.

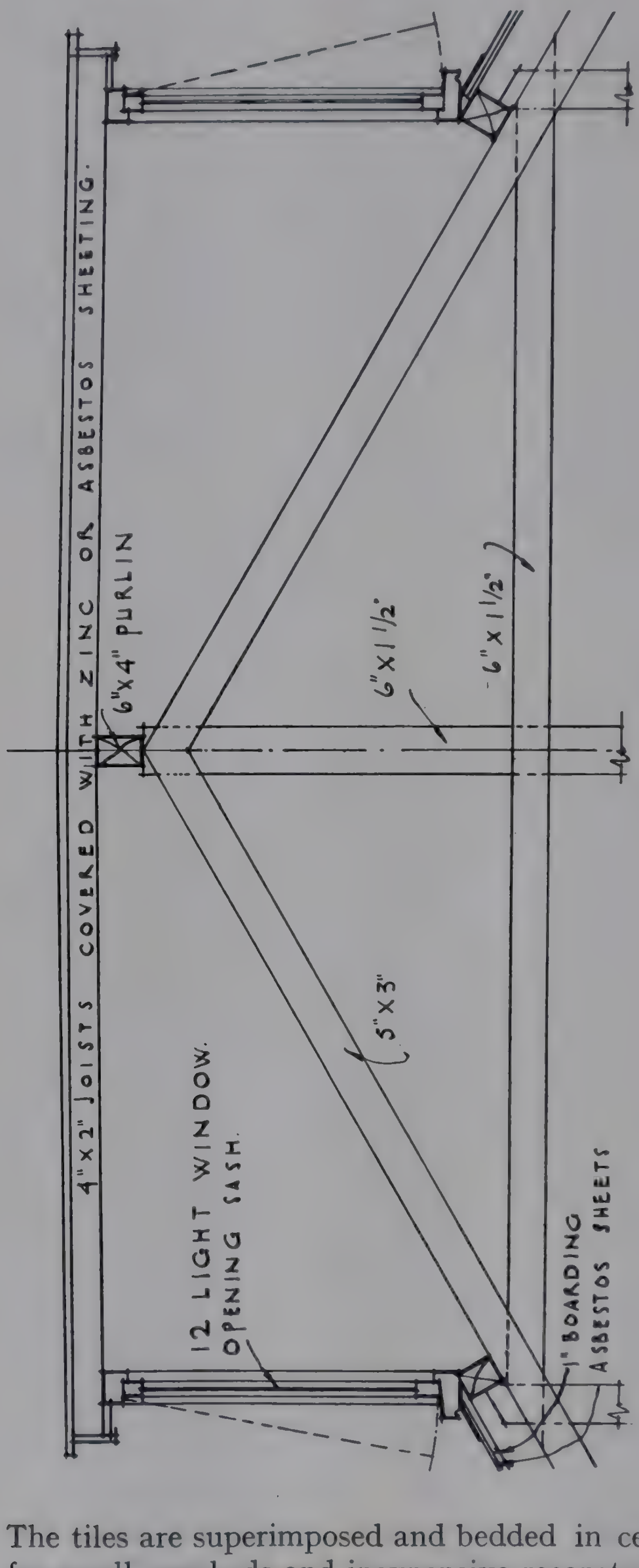

4"x2" JOISTS COVERED WITH ZINC OR ASBESTOS SHEETING.
6"x4" PURLIN
6"x1 1/2"
6"x1 1/2"
5"x3"
12 LIGHT WINDOW.
OPENING SASH.
1" BOARDING
ASBESTOS SHEETS

Fig. 22.

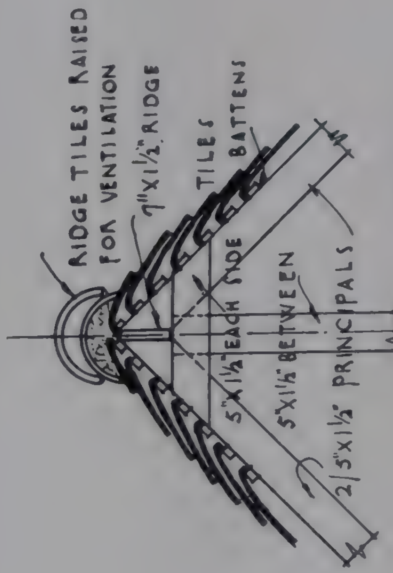

RIDGE TILES RAISED FOR VENTILATION
9"x1½" RIDGE
TILES
BATTENS
5"x1½" EACH SIDE
5"x1½" BETWEEN
2/5"x1½" PRINCIPALS

Fig. 23.

The standard-type ridge ventilator with louvres and glazed roof lights is shown in Fig. 24.

Any of these types of outlet is quite satisfactory and selection is merely a matter of choice. It must be stated, however, that ridge tiles, whilst satisfactory for use in small cowsheds or in reconstruction schemes, could not be described as entirely suitable in a new building. Preference should be given to ridge ventilators which, in addition to clearing vitiated air from the cowshed, also add to the natural lighting of the building. One point should be noted here. The outlets should not be too large, as it is a well-known principle of ventilation that, where outlets are smaller than inlets but have a greater combined area, the fresh air entering is distributed more evenly.

The area of the inlets, apart from windows, should be at least 30 square inches per cow and more if the shed stands in a sheltered position. Inlets in the same manner as outlets should preferably be capable of being regulated according to weather conditions, although this is not absolutely essential. It must be remembered that there will possibly be many occasions when all the ventilation inlets and outlets are not in use together. The standard to be aimed at is the operation of sufficient openings to maintain the air in a fresh condition when all the stock are housed in the building. It should also be borne in mind that windows do not constitute useful aids to ventilation unless all or part open inwards on the principle of the Sheringham valve. In such cases, although a certain degree of ventilation is provided by the windows, it is also essential in every case to provide ventilators in the walls. Generally speaking, these should be placed approximately 6 feet above floor-level. Inlet ventilators are of various types, and those most generally used are as follows:

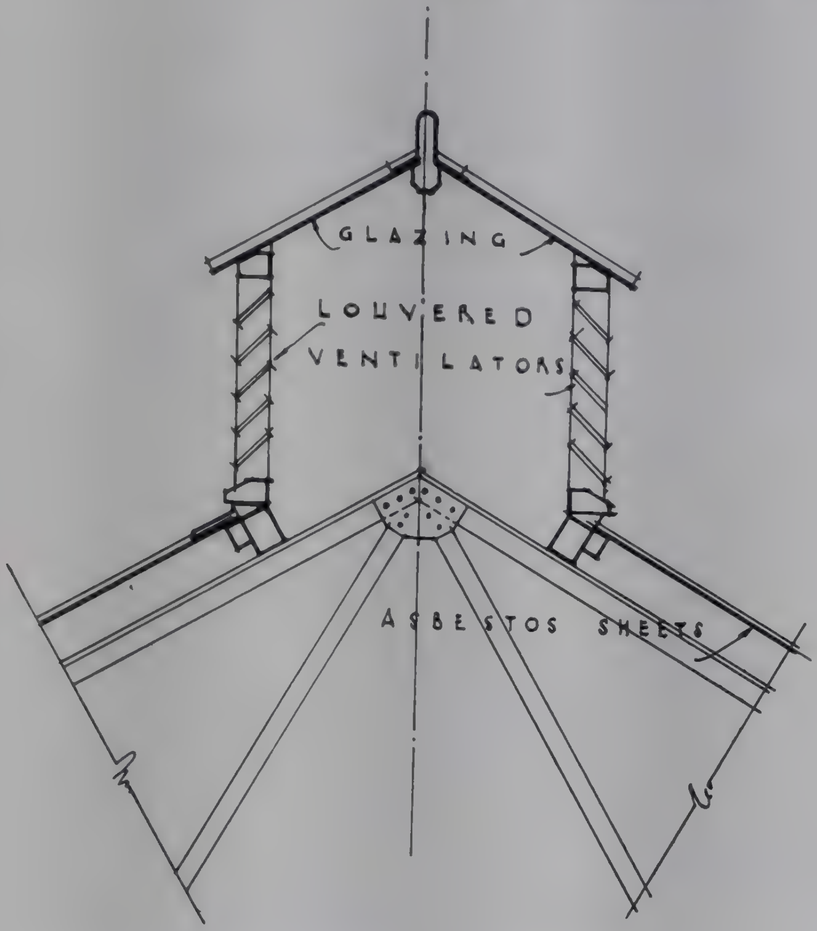


FIG. 24.

(1) Iron grating with regulator on the principle of the Sheringham valve (Fig. 25).

(2) Pipe tiles fixed in the wall with an upward and inward slope, so that incoming air is directed upwards, away from the animals (Fig. 26).

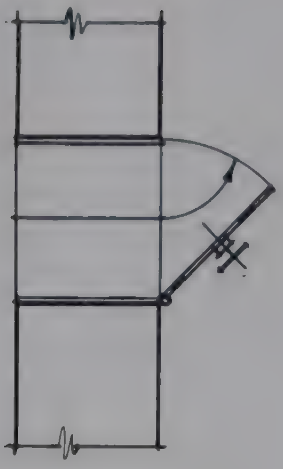


FIG. 25.

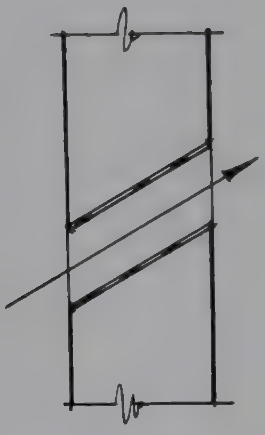


FIG. 26.

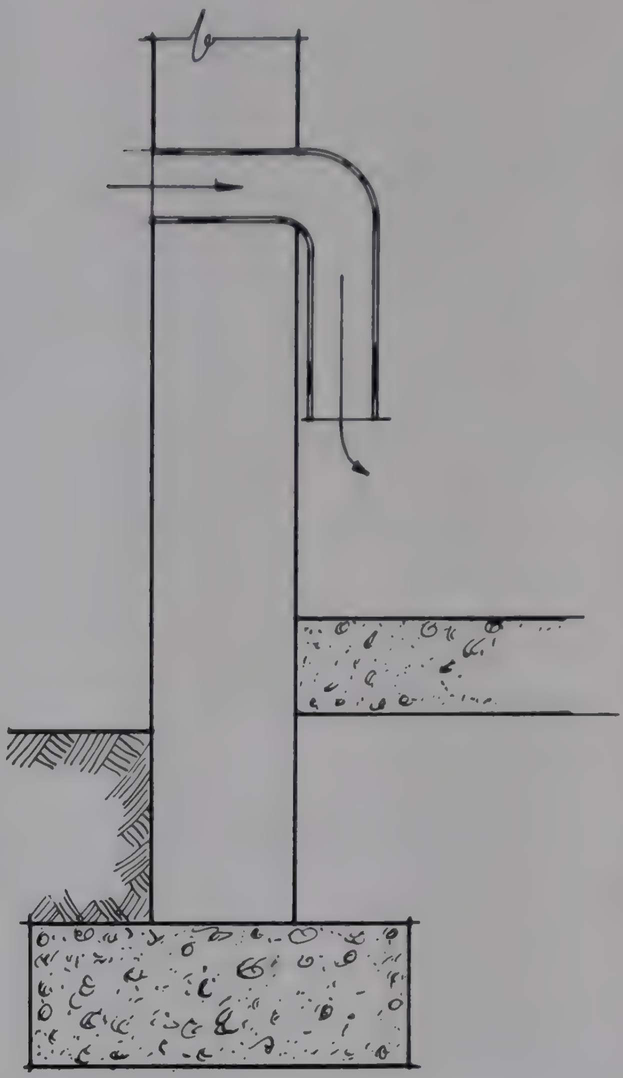


FIG. 27.

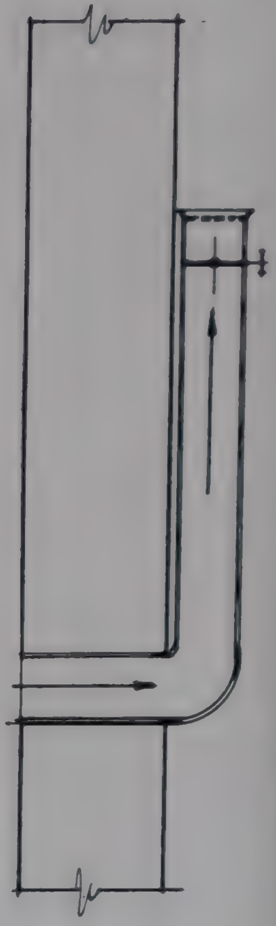


FIG. 28.

(3) Right-angled inlet pipes fixed some 12 to 18 inches above floor-level, deflecting the fresh air on to the floor of the byre (Fig. 27).

Note. In this type the standard recommended height of the ventilators above floor-level is decreased.

(4) Inlets of the Tobin tube type (Fig. 28).

The particular value of these types of ventilators lies in the fact that the incoming air is thrown upwards, and is so prevented from falling directly on to the backs of the animals. Inlet ventilation fixed in the walls as shown in Figs. 17 and 19 are also suitable.

(4) LIGHTING

Natural Lighting. In that portion of this chapter devoted to the aspect of the building it was stated that double-range buildings should run north to south and single-range cowsheds west to east, with a view, *inter alia*, to obtaining maximum natural light. The provision of adequate natural lighting suitably distributed is of no little importance, and care should be taken to ensure that the maximum amount of light falls upon the point where most work is done, i.e. the hindquarters of the cow. With this object in view, it is advisable to arrange for adequate *roof lighting* to be provided in cowsheds in which the animals are arranged tail to tail. Where the animals are arranged head to head, roof lighting is not of such great importance, and the maximum natural light should be obtained by means of windows placed in the walls. Moreover, sunlight, because of its well-known germicidal properties, should be freely admitted into the building. There is no maximum standard for light, but arrangements should be made in the design for a minimum of at least 3 square feet of window space per cow, while a window area equal to one-tenth of the floor space is to be preferred. It is impossible to have too much natural light, but it must be emphasised that roof lighting is of considerably more value than that obtained from windows placed in the walls. Such roof light is free from obstruction by buildings, walls or trees, especially in winter mornings and evenings when it is particularly advisable to obtain all the light possible.

Artificial Light. Whilst natural light is available during a considerable portion of the day, it is not possible to carry out all cowshed operations in winter by its aid. It is therefore necessary to consider the provision of adequate artificial lighting. What is adequate in one district where no *electricity* is available could under no circumstances be considered sufficient where such supply was to hand. The National Grid System of distributing electricity has made great strides, and it is one of the professed aims of those in charge of the scheme to provide cheap light and power for *all agricultural areas*. When this scheme is finally completed, it is hoped that the majority of those agricultural communities may find themselves in the fortunate position of being able to obtain what may be definitely stated to be the best type of artificial lighting, with the added advantages of ample power for driving machinery. Electric lighting is clean, comparatively trouble-free, and, by the provision of suitable lamps properly placed, can supply all the light necessary for work in the cowshed at any time of the day or night. It should be stated, however, that a cheap installation is liable to be dangerous and more costly in the end. As with natural lighting, the maximum artificial light should be placed at the hindquarters of the cows.

It is to be deplored that there are still many farms in our rural areas where no electricity is available, this being generally the prerogative of the suburban and semi-urban farmer. This is due to apathy on the part of many power companies, the regulations regarding overhead cables, the high charges which may be incurred in connecting the farm to the grid, and the cost of the current. So long as this holds, farmers would be well advised to consider the question of producing their own electric current by means of one of the many proprietary plants to be obtained for this purpose. A modern Diesel-engined generating plant will produce electricity at an all-in cost of approximately 1*d*. per unit. The first cost of the plant is fairly heavy but is less in many cases than the charge made to connect a farm to the grid system.

Many semi-urban cowsheds make use of *gas* as a means of providing sufficient artificial light. This is an unsatisfactory method, not only because of its dangerous qualities and the risk of fire, but also by reason of the by-products of combustion which pollute the atmosphere of the cowshed. This type of lighting also requires considerable attention if it is to be successful, while the cost of renewing incandescent mantles is excessive.

It is still the practice in many areas for the milking and other cowshed operations to be carried out by means of light provided by the old-fashioned *hurricane lamp*. These lamps can only be described as inadequate for clean milking. They do not give a sufficiently bright light and require constant attention. If a lamp or lamps must be used, there are various proprietary makes of *paraffin vapour lamps* now obtainable which are much more suitable. Such lamps are economical, safe, and give a brilliant light which is adequate for all purposes.

(5) CONSTRUCTION AND FITTINGS

Walls

The walls of a cowshed may be built of a variety of materials, and choice will naturally fall upon those most easily available in the district. Suitable concrete foundations should be provided, and the height to the eaves should be at least 8 feet. All the angles between the floors and the walls should be rounded off so that there are no crevices to collect dust and dirt. For the same reason, the walls should be built or boarded up to meet the roof without leaving any open spaces or ledges. The material of which the walls are constructed should be such as can easily be cleansed, disinfected, or limewashed. Such materials are :

(1) *Brick or Stone.* Brick or stone walls, whilst more expensive to construct than certain other types, are more durable. If desired, the wall may be faced internally with glazed bricks which give a most satisfactory finish, although, unfortunately, the expense attached to this method of construction precludes it from general use. An alternative and cheaper method is to render the wall to a smooth finish with cement and sand ½ inch thick to a height of 4 feet 6 inches. The brickwork above should be finished with flat joints and limewashed. The rendering may if desired, be carried up to the full height of the walls, but if this is done, the rendering above the height of 4 feet 6 inches should be finished off with a wooden float, to a rough surface. This surface will hold the limewash and help to minimise the condensation which takes place on smooth surfaces under certain atmospheric conditions. When undressed stone is used, it is always necessary to finish off with a cement rendering. Brick walls may, if desired, be finished with flat joints and tarred to a height of 4½ feet above floor-level. Above this, the walls should always be limewashed. It is not advisable to limewash down to the floor-level owing to the splashing of water used in washing, and possibily dung and urine.

(2) *Reinforced Concrete.* This material gives a durable wall. In constructing this type of wall, steel joists are erected at equidistant intervals, and steel wire is then threaded longitudinally through apertures in the joists, 6 inches apart. Shuttering is next erected and the concrete poured in, the wires acting as reinforcement. The internal surface should be rendered in cement and sand up to the roof, the lower portion being tarred or left bare as desired, and the upper portion limewashed. This is a reasonably economical type of wall. If desired, the concrete can be erected up to the window level only. The rest of the wall is then carried up to the required height by means of framing, and finally glazed, this affording the maximum amount of light.

(3) *Concrete with Wooden Posts.* A similar but cheaper wall may be erected by using stout wooden posts instead of steel joists, and filling in with concrete reinforced with steel wire. The wooden posts should be creosoted under pressure before use. This method of preservation is well worth the extra cost incurred.

(4) *Breeze Blocks.* This type of wall is economical but cannot be termed durable, while its strength is insufficient for any but small cowhouses. Particular care should be taken to ensure that the breeze has been thoroughly washed before being made into blocks. The internal surface must be rendered to give the required smooth finish and, if desired, the outside may be treated in a similar manner to improve its appearance. *Concrete blocks* are superior to breeze blocks for this form of construction, being stronger and more durable.

(5) *Wood or Steel Frame Buildings.* A cheap cowhouse may be erected by using a wood or steel framework covered with asbestos sheeting. Steel erections are more expensive, but more durable. This type of building is not to be recommended for any districts which experience severe winters. As this material cannot be rendered internally to give an impervious finish, it is necessary to widen the dunging passage if this adjoins the walls, to prevent the soiling of the internal surface.

(6) *Brick, Stone, or Concrete with Wood or Asbestos.* A very desirable cowshed can be erected by the use of these materials in conjunction one with the other. The brickwork, etc., is carried to a height of 4½ feet. On this is erected a wooden

or steel framework, which may be covered externally with boarding or asbestos sheeting. This type of erection combines the advantages of economy and cleanliness. The timber should, as before, be creosoted under pressure.

Note. The concrete used for the erection of walls should consist of 1 part cement, 3 parts sand, and 6 parts aggregate (granite, shingle, or crushed stone).

Prefabricated concrete buildings are now obtainable and their employment deserves serious consideration. Such erections are low in cost in comparison to other permanent structures. They are admirably suited to speedy erection and provide suitable housing for dairy cattle.

There is one detail regarding the walls of cowsheds which concerns all producers, and that is *limewashing*. This is compulsory under the Milk and Dairies Order, 1926, whether the buildings be old or new. If properly carried out, the limewashing of the cowshed is no mean task, and the work entailed in covering a large wall area requires a considerable amount of labour and expense if undertaken by hand. For this reason a good type of *limewashing spray* which considerably reduces both the labour and the cost is an economic investment. A small quantity of disinfectant should always be added to the limewash.

Roof

Roofs require to be both permanent and non-conducting, and may be of various types.

Thatched roofs have the advantage of being cool in summer and warm in winter. It is perhaps to be regretted that thatching is a fast-dying art, although this type of roof had the disadvantage of accumulating dust and becoming verminous, while by the gradual decay of the materials, it also tended to become a constant source of contamination. A thatched roof should always be cased in on the under-surface with match-boarding, three-ply wood, or asbestos.

The best materials to use in roof construction are either *slates* or *tiles*, and these materials should be generally adopted. Where tiles are used, the roof timbers require special attention owing to the extra weight which they have to bear, while the roof should also be underdrawn in each case. A higher ridge is required than for slates or other materials. The day of heavy roof timbers has gone, and in their place roof trusses built of light steel, asbestos or scantling are now in general use.

Corrugated asbestos sheeting is light and durable, and can be used to form a serviceable roof. In this case it is necessary to set out the roof trusses for a particular size of sheet. This material can be laid at a flat angle on wide-span buildings. *Corrugated galvanised iron* possesses the same advantages, but has numerous and serious drawbacks. This type of roof produces extremes of temperature and, unless frequently painted or tarred, is not permanent, especially in suburban areas or in towns, since the material slowly perishes. Corrugated-iron roofing also allows condensation to take place on its smooth under-surface. The condensed moisture tends to drop on the animals, while the floors are liable to be continually damp, especially during certain changes of weather. This type of roofing, if used, should always be lined with some non-conducting material. Roof lining need not necessarily be used with other types of roofing material, but it is usually advisable to carry this out, as a smooth under-surface is much easier to limewash and to keep clean.

With roofs of larger span some *supports* may be found necessary. Steel supports can be erected on similar foundations to those provided for the walls, and should be so placed as not to interfere with the internal arrangements and working of the cowshed.

Floors and Standings

The essential qualities of a good floor are as follows :

(1) Non-absorbent.
(2) Easily cleansed.
(3) Non-slippery and waterproof.
(4) Warm.
(5) Durable.

The chief and most common type of floor material is *concrete*. Floors may also be laid of *Staffordshire blue bricks* jointed with cement and possessing a concrete foundation. There are also proprietary floor bricks, composed of a mixture of *cork asphalt* jointed with *bitumen*. Floors of *resilient rubber* are also used, and it has been found that a greater output of milk may be obtained by replacing a hard floor with one of this type. The output in such cases is said to increase by as much as 15 to 20 per cent., while the floor is undoubtedly more comfortable for the animals. Floors composed of cork asphalt bricks or rubber are entirely satisfactory, but rather expensive, and this fact has so far prevented their more general use. Concrete floors are reasonably cheap to construct, and in practice fulfil all the requirements enumerated above. Suitable insulation should always be provided by the use of agricultural pipes as shown in Figs. 16–19. When such a floor is provided, the work of cleansing is reduced to a minimum. The whole of the floors and standings can be hosed down and, during the summer months when the animals only come into the cowshed to be milked, it is possible by this means to keep the byre cool and so prevent the possibility of floor dust obtaining access to the milk.

There are three much-voiced objections to the use of concrete as a flooring material. These are :

(1) Such flooring is damp and cold for the animals.
(2) It tends to become slippery.
(3) It causes the animals to suffer from " big knee."

If the floor is properly laid, it can never be said to be cold or damp, and such floors are only slippery if not kept clean. In any case, if carborundum dust is trowelled into the finishing coat, a non-slippery, hard-wearing floor will be obtained. There is, in some quarters, a decided prejudice against the use of concrete right up to the feeding-trough. Many farmers prefer to use rammed clay, short rubble, or cork asphalt bricks for a space of 2 to 3 feet in front of the feeding-trough as a preventive against " big knee." Against this is the known fact that rubble or clay becomes very foul and offensive, and must be frequently renewed. Cork asphalt only should be used for this purpose, there being no objection to this material. There does not, however, appear to be any justification for the belief that the use of standings constructed entirely of concrete causes this trouble. Some cases no doubt may be due to this type of floor, but in all probability more are brought about through other means. If the cows are provided with a sufficient amount of bedding, there is no objection to concrete being used throughout and straw is in plentiful supply at the present time.

Before laying the floor of the standings and passages with concrete, care must be taken to obtain a thorough drainage of the site and a uniform evenness and firmness of the foundations. A foundation of 6 inches of broken stone, brick or gravel should first be laid down and the necessary insulation placed in position. Concrete composed of 1 part cement, 2 parts sand, and 4 parts aggregate should be super-imposed on this to a depth of 4 inches, and well rammed. A finishing coat of 1 part sand to 1 part cement should then be laid while the concrete is still green, to a depth of 1 inch. The whole then forms one solid mass and, whilst the finishing coat is still wet, the surfaces of the standings and passages may be grooved diagonally to give a foothold for the animals. This, however, adds to the cost of the work and is not essential. If the surface is finished with a wood float and brushed over with a stiff broom before setting, the result is quite as satisfactory and the cost much lower. The broom should be drawn from the feeding-trough towards the gutter, thus facilitating drainage. The standings and passages should be given a lengthwise fall of approximately 1 inch in 40. During the laying of the floor, care must be paid to the rounding off of all angles and corners, with the exception of those at the edge of the gutter, this being done to prevent the accumulation of filth and to afford easy cleaning.

Gutters

Properly constructed gutters are essential to secure satisfactory sanitation in the cowshed. They should be constructed of concrete, and be laid following the construction of the standings and the passage, They should be of adequate size and depth to prevent fæces or urine splashing back on to the standing or on to the milking passages and walls, and should be provided with a sufficient fall to facilitate drainage. Figs. 29–32, show the four types of gutters found most satisfactory for general use.

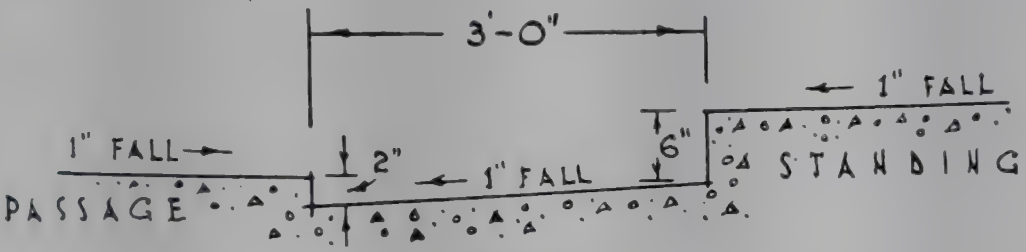


FIG. 29.

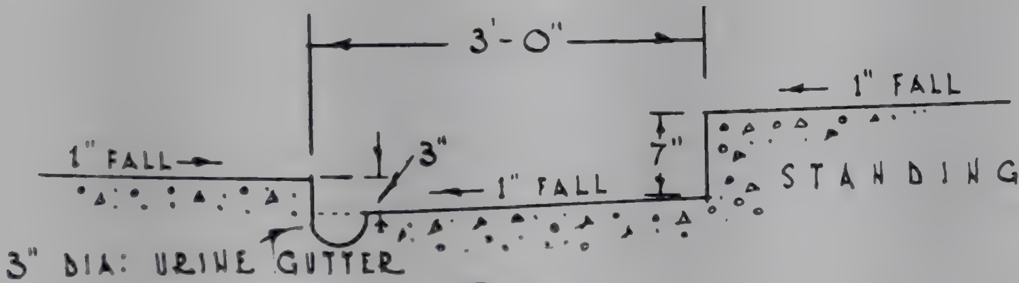


FIG. 30.

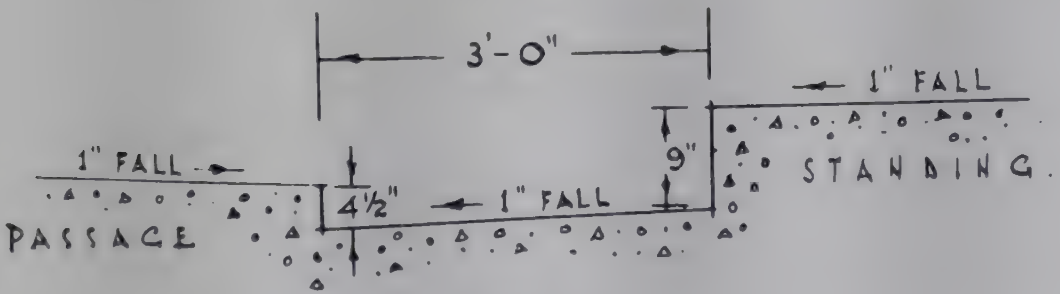


FIG. 31.

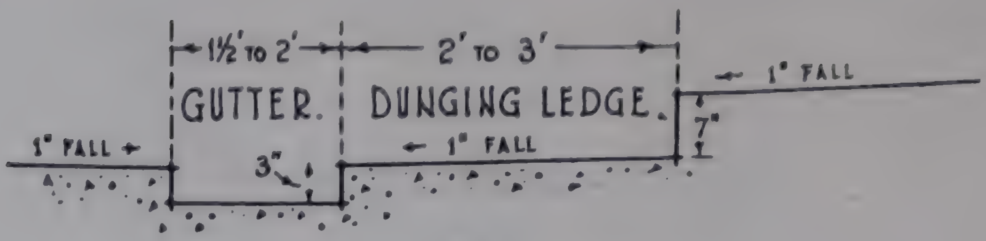


FIG. 32.

The standings should be raised at least 6 inches, preferably more, and the milking passages at least 2 inches above the bottom of the gutters. This depth prevents the animals' tendency to stand back with their hind legs in the bottom of the gutter, and also prevents the splashing of manure and urine on to the floors and walls. The gutters should never be less than 2 feet 6 inches in width, an increase up to 3 feet being desirable. Efficient drainage is thus secured, while this width prevents the liquids being held up in pools by deposits of dung. A further advantage of a wide gutter is the fact that the animal will walk into the gutter before stepping on to the standing. Cows will always tend to jump across a narrow gutter and, in doing so, may slip and seriously injure themselves. The gutters should have a fall of at least 1 inch from the standing to the passage, while a longitudinal fall of 1 foot in 40 should be provided to ensure that all liquids drain to one end of the cowshed and so into the drains. If preferred, a small channel 3 to 4 inches in width, as shown in Fig. 30, may be provided with a view to removing the liquid. Such channels are, however, liable to become choked with manure, and in this condition cannot efficiently perform their function. The upper edges of the gutter should be left sharp to prevent the animals slipping when stepping on and off the standings.

Fig. 32 illustrates a *dunging ledge* constructed between the standing and the gutter. When this is provided, dung is deposited on the ledge while urine is drained away. Any tendency for the gutter to become choked with manure is therefore obviated. The drainage gutter in this instance need not be more than 2 feet in width.

Feeding-troughs

The feeding-trough should always be constructed of concrete finished with a smooth surface. It should possess no corners to accumulate scraps of food. Fig. 33 shows a section through a standard type of trough.

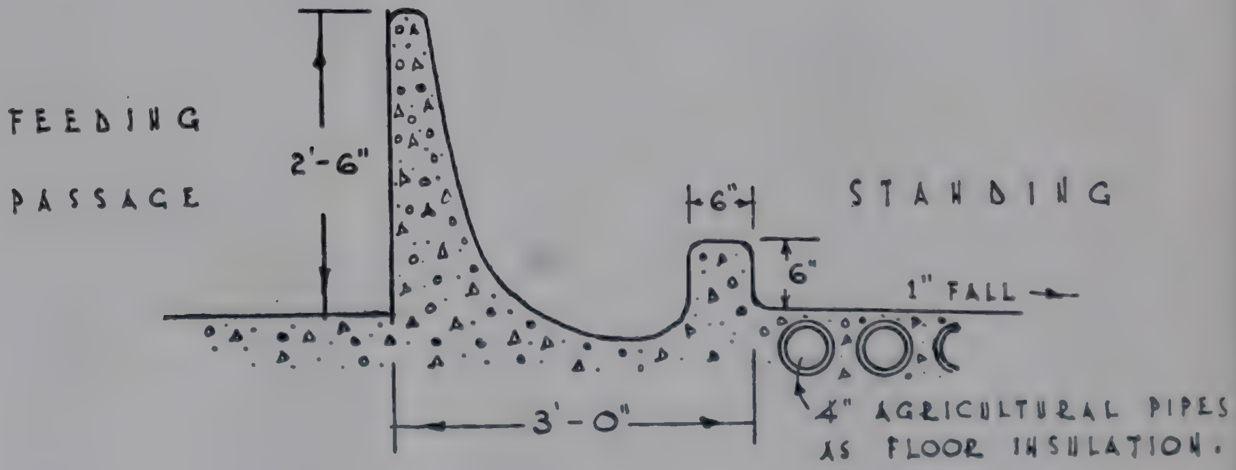


FIG. 33.

The advantages of this type are :

(1) It can easily be washed with water from a hosepipe, or with buckets of water if no hose is available.

(2) Sweeping is facilitated.

(3) The food falls towards the animal and so prevents it straining forward on its knees while feeding. This is one of the known causes of "big knee" and other injuries.

(4) The drop into the feeding passage, where one is provided, allows any food pushed forward by the animal to drop out of sight. Food which the animal can see but cannot reach worries it and causes it to strain forward.

(5) The animal is able to dispose easily of all the food in the trough.

To sum up feeding and cleansing are adequately simplified.

The feeding-trough should be 2 feet 6 inches wide from the feeding passage or wall, as the case may be, to the kerb. The kerb should be 6 inches high above the floor of the standing and 4 inches thick, and it should be built in one length. It may, however, require to be cut to take certain types of steel yokes, as shown in Figs. 40 and 41. This width of trough provides the animal with sufficient head room, while the low kerb allows it to lie down in comfort with its head over the trough. The trough should have a slight fall in a longitudinal direction, and a plug should be provided at the lower end to drain off washing water.

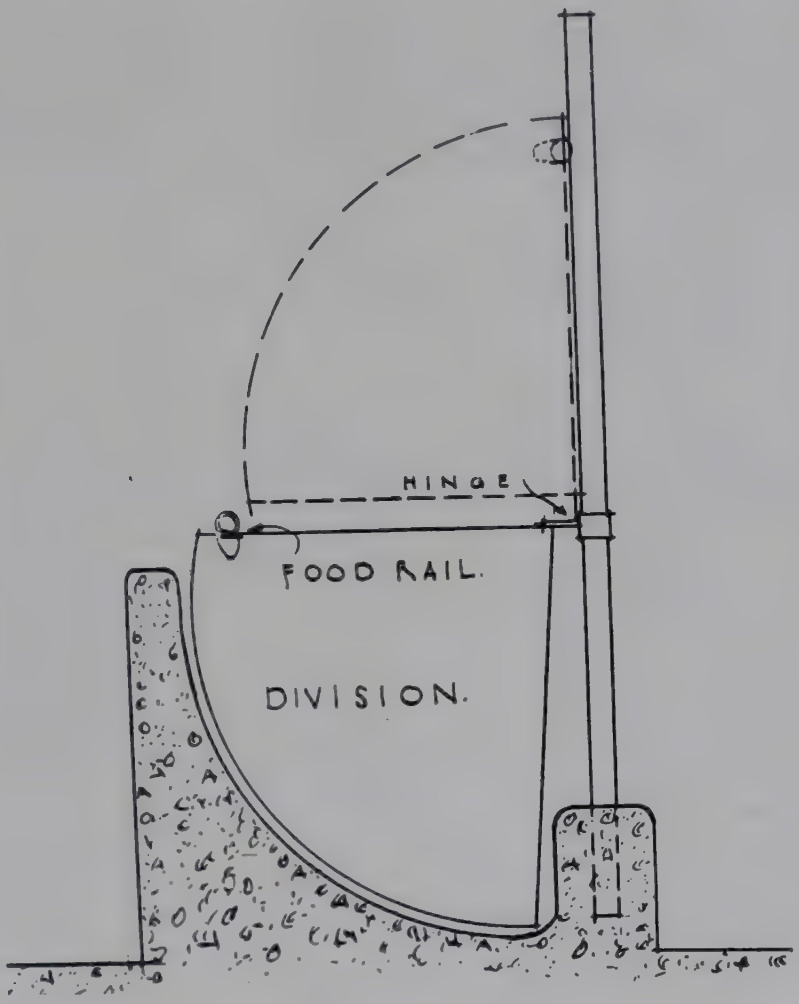


FIG. 34.

When feeding passages are provided and the cows tied up by chain, it is usually necessary to provide a *head rail* to prevent the animals moving forward with their heads beyond the feeding-trough. If they are allowed to do so, the standing will become fouled with dung.

Manger divisions are useful fittings which divide the feeding-trough and so provide a separate compartment for each animal. They are usually constructed of galvanised iron, and can be raised and lowered to facilitate the cleansing of the trough. *A food rail* running the full length of each set is attached to the divisions, level with the top of the trough, so preventing food being pushed over into the feeding passage by the animals. The advantages to be obtained from fitting these divisions are :

(1) Each animal can be given the exact amount of food it requires. This makes for economy and, as feeding-stuffs are expensive, any saving in this direction should be considered.

(2) Animals which are gluttonous eaters and bolt their food often steal that of their slower neighbours. Manger divisions thus prevent over- and under-feeding, either of which is harmful to the animal.

Fig. 34 shows a section of a feeding-trough with manger division and food rail.

The food rail may be attached to the feeding-trough if divisions are not fitted. The divisions may be raised either by hand, by counter-balance weights, or by windlass and chain. If raised by hand or by weights, they are best made in sets of three or four divisions.

Doors

Doors have to be provided for the entrance and exit of the cattle, and may either be hinged or made to slide. *Hinged doors*, which should always be hung in halves, are not recommended for new erections. They tend to slam in strong winds, with consequent damage to themselves, their hinges, and the walls of the building, besides being difficult to open following heavy snowfall. *Sliding doors* are neat in appearance, and suffer from none of the disadvantages of the hinged variety. In addition, they may be made self-closing by the provision of weights. Whichever type of door is used, the article should be of simple construction and strongly made. The usual sizes are :

Single—7 feet high by 4 feet wide.
Double—7 feet high by 8 feet wide.

Where hinged doors are provided, all the angles of the door frames should be rounded off. In the case of sliding doors, round-nosed bricks should be substituted for ordinary bricks at all angles. Rounded-off corners are necessary to prevent any risk of injury to the animals.

Windows

The provision of suitable windows is essential for the supply of adequate natural light to all parts of the cowshed, and it is always preferable that there should be too many rather than too few. A well-lighted building is definitely more sanitary than one which is badly lighted, besides being warmer and drier. The windows should not be less than 4 feet 6 inches from the level of the floor and, if continuous window lights running the full length of the byre are not provided, the separate sashes should not be more than 3 feet apart. Windows fixed in the walls should be of the bottom-hung, casement-sash type, while frames and sashes may be constructed of either wood or steel. Many new buildings are being erected with steel window sashes and frames, and, as these are very durable and also fireproof, their use should be encouraged. Windows should, wherever possible, be of the hopper type, that is, provided with *side shields*, as illustrated in Figs. 35 to 37.

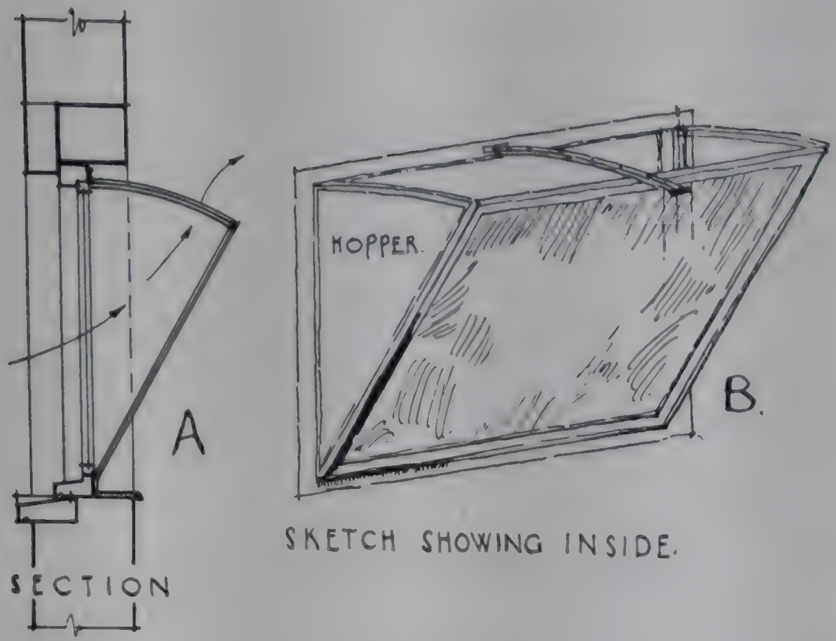


FIG. 35.

The side shields are provided to deflect the incoming air in an upward direction, thus preventing draughts on the backs or heads of the animals. The hopper windows should open and close by means of ratchet fittings.

Provision must always be made for windows to be fitted in the gable walls, and also for adequate roof lights of the type illustrated in Figs. 21, 22 and 24.

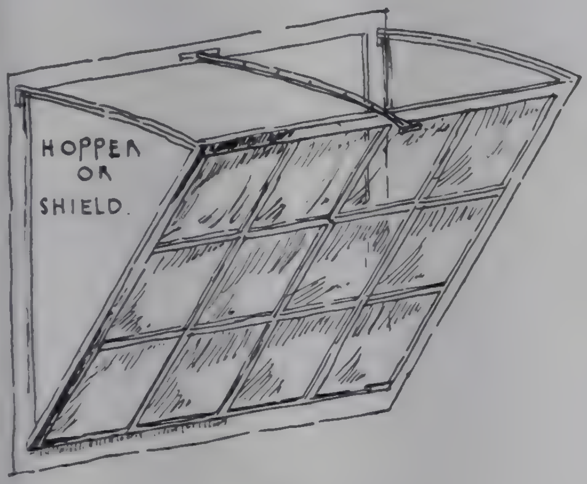


FIG. 36.

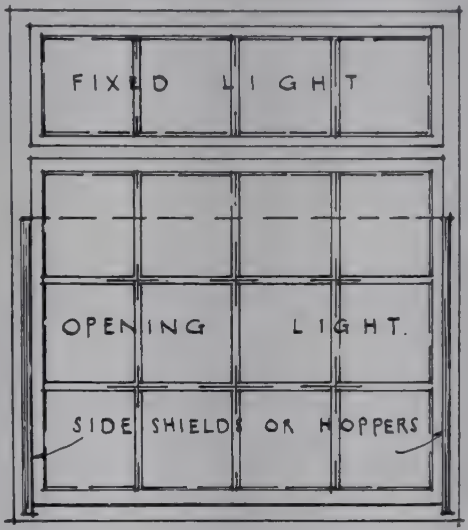


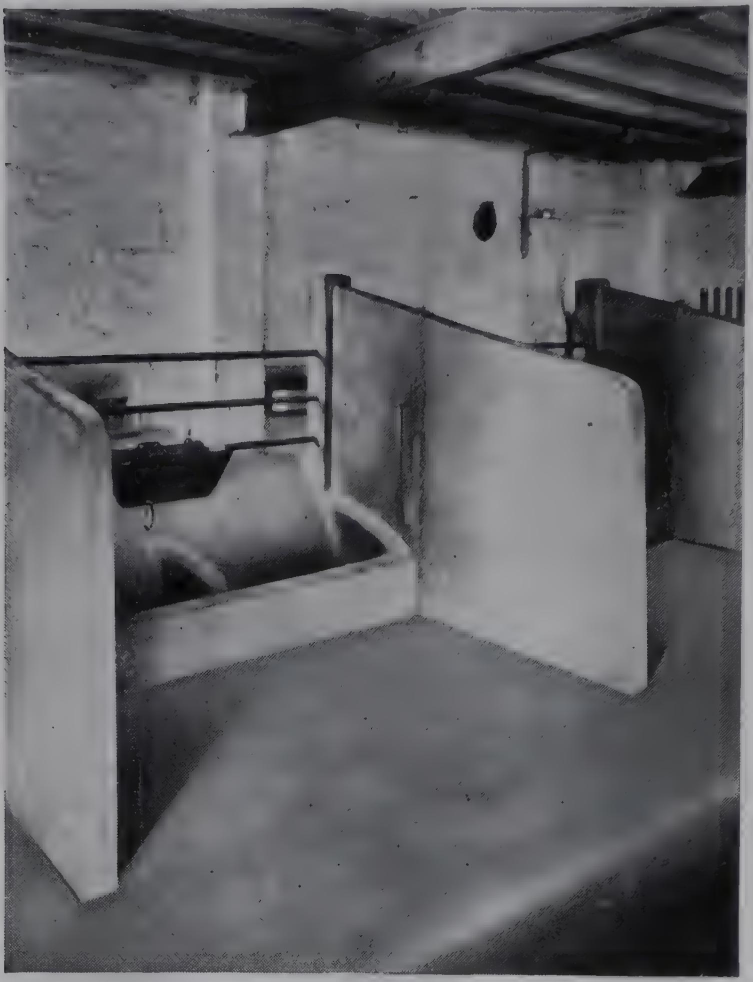
FIG. 37.

Provision should be made for opening these windows by means of screw-opening gear fixed at floor-level.

Divisions and Yokes

Divisions of wood, concrete, or slate are often found in old cowsheds, the usual number being one division to every two cows. *Wood* should on no account be used. If this type of stall is used in conjunction with concrete floors, that portion of the wood in contact with the floor will absorb moisture, causing the material to swell. As the woodwork ages it contracts, leaving a crevice between the division and concrete which almost invariably becomes filled with filth. The woodwork eventually rots and requires replacement. Wooden stalls also harbour vermin and encourage disease.

Concrete or *slate* divisions are preferable to those constructed of wood, but they possess the disadvantage of obstructing the free flow of air and causing many dark corners which are difficult to cleanse. With this type of division, each animal is fastened by an ordinary chain fastener attached to an iron rod socketed into the division. Divisions of this type are cheap and durable. The great advantage of the chain is that it allows the animal to move back and stand in the gutter, or forward, when it may foul the standing with dung. Owing to the fact that it is extremely difficult to obtain steel divisions at the present time, the use of concrete for this purpose has considerably increased.



By courtesy of the Cement and Concrete Association.

FIG. 38. Cowshed showing Solid Reinforced Concrete Divisions.

There can be no doubt that *galvanised steel tubular* divisions are best for all purposes but, as mentioned above, these are difficult to obtain. It is an accepted fact that each animal should be divided from its neighbours to prevent interference and to allow each cow to lie or stand in peace. The troubles due to rough neighbours are thus prevented and a continual source of irritation removed. When used with steel yokes, this type of division is ideal. Fig. 39 shows tubular standings with steel yokes, of approved pattern.

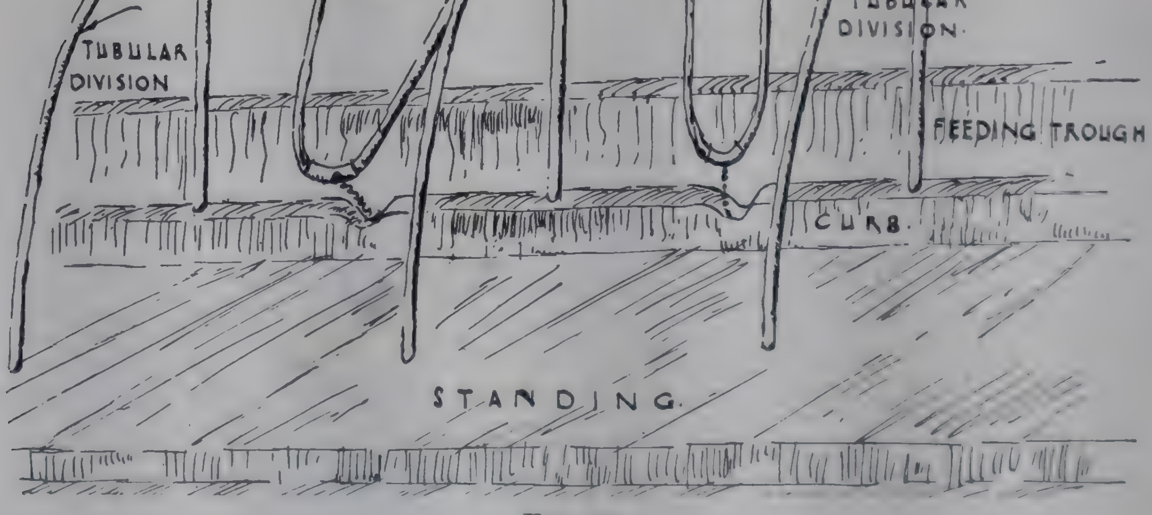


FIG. 39.

The *yokes* may either be hung by chains from galvanised tubing running the length of the byre, or attached by a clip and swivel arrangement to the top rail. Yokes provided with an aligning device so that the animals may be lined with the gutter are to be preferred. This device is also useful for the various sizes and ages of animals. Perfect alignment is necessary to prevent the animals fouling the standing or placing their hind feet in the gutter. The yoke opens by means of a thumb-operated catch, and, when open, rests against the upright, as shown in Fig. 39. It fits, when in use, close to the shoulders of the animals.

The advantages obtained from the use of tubular divisions and yokes may be detailed as follows:

(1) Each cow is tied in the centre of the stall, and complete freedom of movement is given to the animal to move its head. It can lie down naturally and easily on either side, and there is no weight on the neck.

(2) The animals are lined up with the gutter when standing, giving them the advantage of a clean stall, as the manure falls into the gutter and not on to the standing. The animals are more easily cleansed and kept clean, and they are kept forward, away from the gutter, when lying down.

(3) Separate divisions prevent an animal interfering with the comfort of its neighbours. Comfortable animals mean a more satisfactory milk yield.

(4) Considerable time and labour are saved in keeping the cowshed clean. The divisions do not collect dirt or harbour vermin, and can be easily washed. Work is saved in bedding the animals and washing the cattle stands.

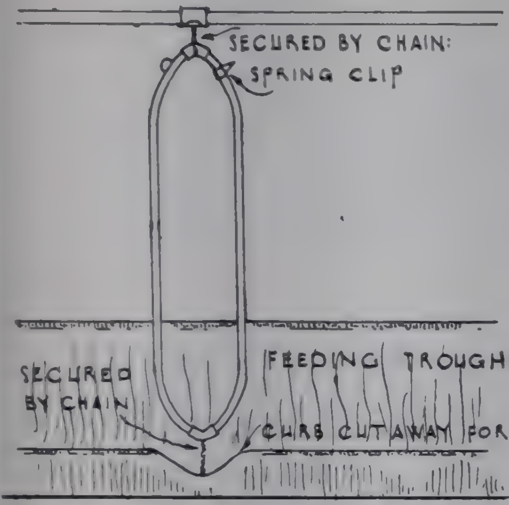


FIG. 40.

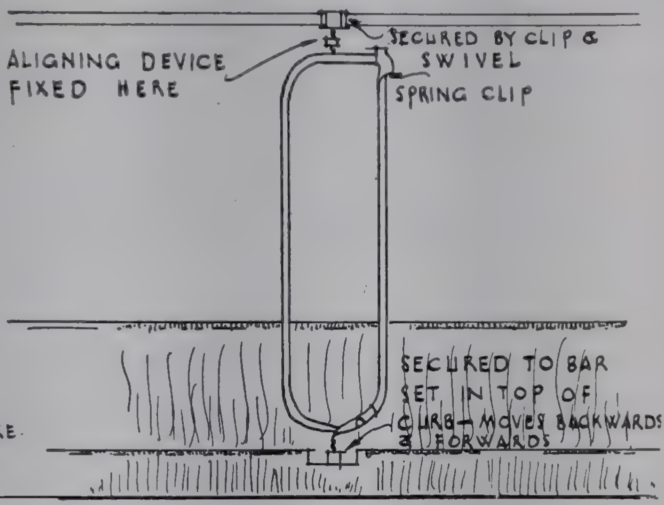

SECURED BY CLIP & SWIVEL
ALIGNING DEVICE FIXED HERE
SPRING CLIP
SECURED TO BAR SET IN TOP OF CURB — MOVES BACKWARDS & FORWARDS

FIG. 41.

(5) The yokes are easily opened and closed from the feeding passage. They can be opened with one hand to allow the cow to withdraw its head when leaving the cowshed. The movable leg rests on the upright when open, and is left in this position until the cow returns to the building. On returning, the animal, in putting its head forward over the feeding-trough, also puts its head in the open yoke, which can be quickly snapped shut. The locking arrangement cannot be unfastened by any action of the cow.

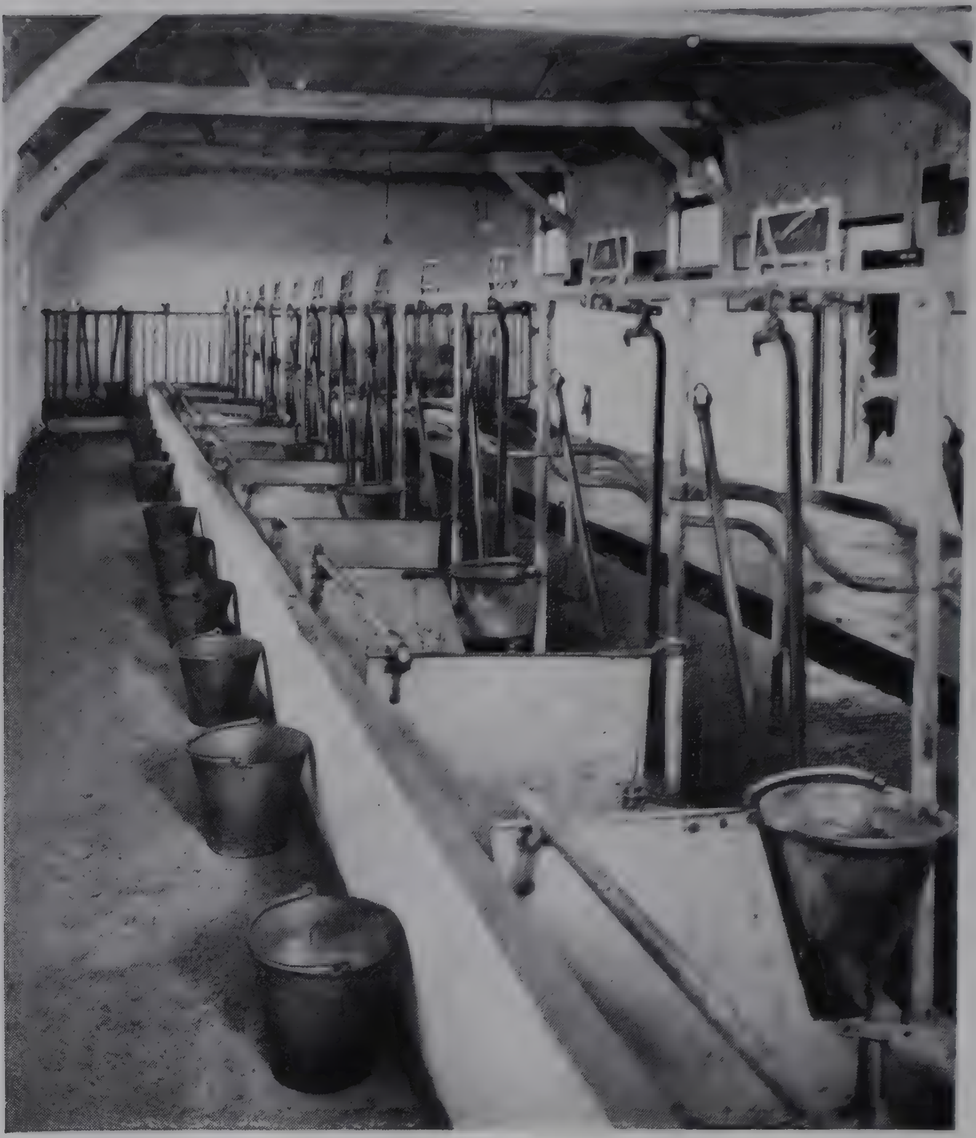
(6) The materials used are durable and of good appearance.

(7) The fittings save space and do not require frequent repair.

(8) This type of yoke holds the cow well forward, so that the length of the standing may be decreased 6 inches. The saving in cost of construction thus effected would probably pay for the extra cost incurred in fitting.

(9) The divisions do not prevent the free flow of air throughout the cowshed, nor do they prevent light reaching all parts of the standing.

If the yokes are chain-hung, it is sometimes necessary to hollow out the curb, but this is not required with the other types. Figs. 40 and 41 show two types of recommended yoke.



By courtesy of the Cement and Concrete Association.

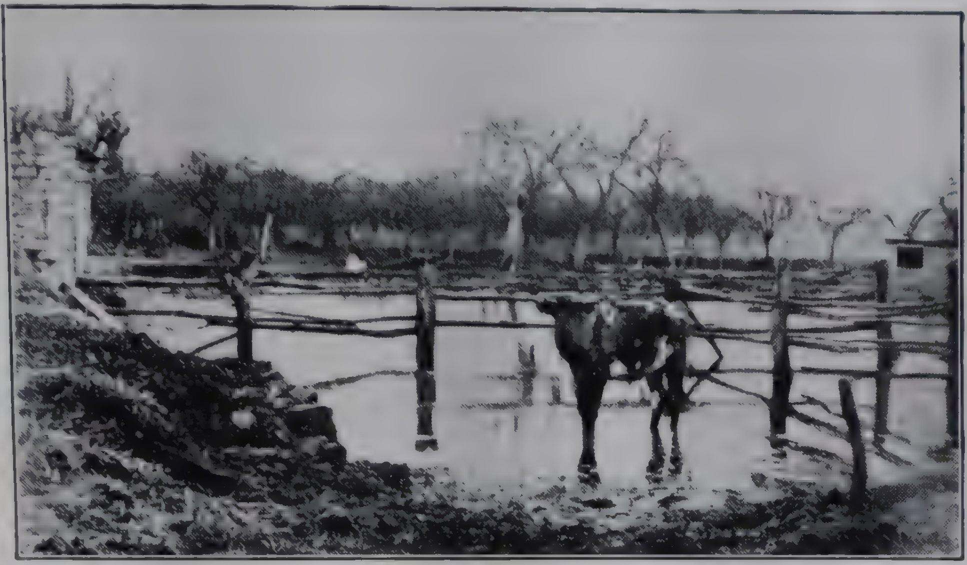
FIG. 42. Modern Cowhouse showing Yokes and Drinking Bowls.

Tubular yokes may also be used with concrete divisions if required, and are a definite improvement on the chain and staple fastening still to be found in many cowsheds.

(6) WATER SUPPLY AND DRAINAGE

Water Supply

It is only within comparatively recent years that the importance of a satisfactory water supply has been recognised, apart from the quantity of water which an animal must drink. It was previously argued that cows appeared to take no harm from drinking the dirtiest of waters, and, in consequence, no standard of cleanliness for water supplies was thought necessary. Evidence has now accumulated to support the view that a pure water supply is of vast importance and this fact has been recognised by the Government. Grants are provided by the Ministry of Agriculture and Fisheries through the various War Agriculture Executive Committees up to 50 per cent. of the cost of approved schemes of water supply to agricultural land and buildings. Schemes may include such works as connections with existing water mains, sinking of wells, installation of pumping machinery, reconstruction of reservoirs, supplies to drinking troughs in fields and laying of the necessary pipe communications. The improvement in existing water supplies has resulted in a marked decline in the number of animals suffering from Johne's disease, and also in the number of losses therefrom. Further, although the effect of contaminated water in the spread of other diseases such as tuberculosis, abortion, etc., may not be so readily recognisable, there are many engaged in the eradication of these diseases who feel that in this direction a great stride could be taken towards their object.

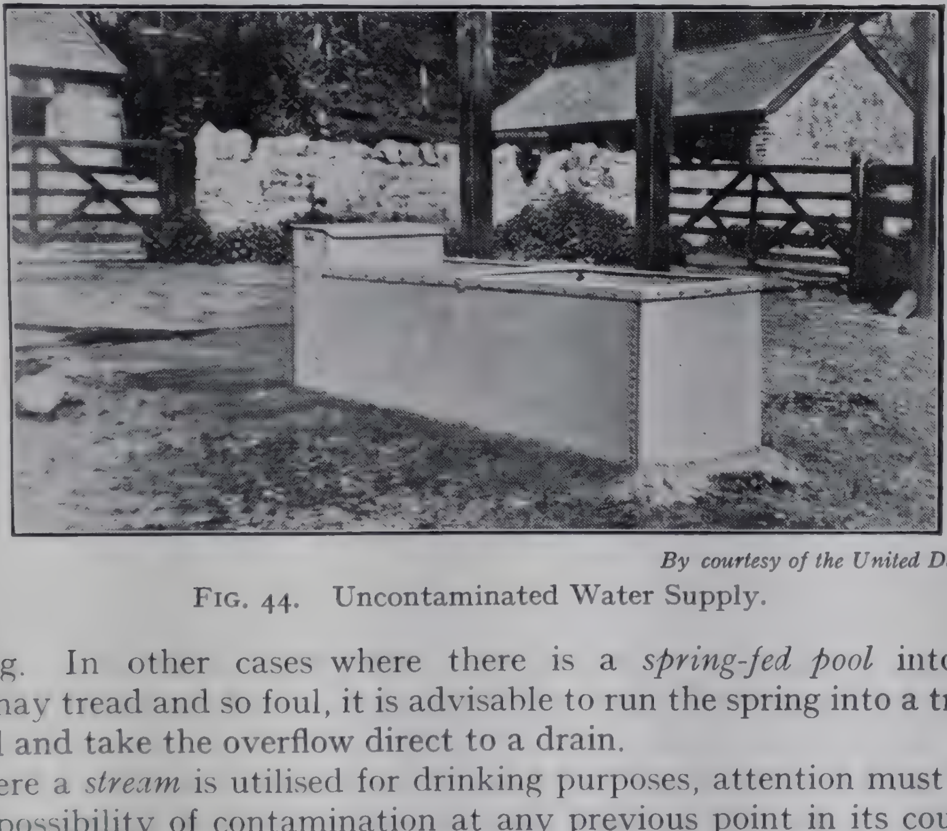


By courtesy of the United Dairies Ltd.

FIG. 43. Contaminated Water Supply.

There is little doubt that research work which has been undertaken with regard to the eradication of tuberculosis has further emphasised the importance of water supplies.

In some cases, where the drinking water is situated in *fields* or *ponds*, it may be sufficient to fence off the margin, leaving enough room for cattle to drink, but preventing any standing in the water, with consequent fouling by dung. In other cases where there is a *spring-fed pool* into which cattle may tread and so foul, it is advisable to run the spring into a trough or channel and take the overflow direct to a drain.



By courtesy of the United Dairies Ltd.

FIG. 44. Uncontaminated Water Supply.

Where a *stream* is utilised for drinking purposes, attention must be paid to the possibility of contamination at any previous point in its course. If the stream is of sufficient volume and speed to reduce any ordinary contamination to a negligible quantity, it need not concern the producer. On the other hand, small streams frequently bring with them unrecognisable organic effluents which render the water unsafe for cattle. Dirty watering-places not only harbour disease, but also soil the udders, which fact militates against the production of clean milk and encourages the spread of mastitis.

An ample, *pure* water supply is therefore necessary both for the use of the animals and as an aid to cleanliness. The amount of water required per animal, per day is approximately as follows:

Drinking purposes	25–30 gallons, approximately nine times the milk yield
Cleansing cowshed, dairy and equipment	10–15 gallons
Milk cooling	6–7 gallons per gallon of milk

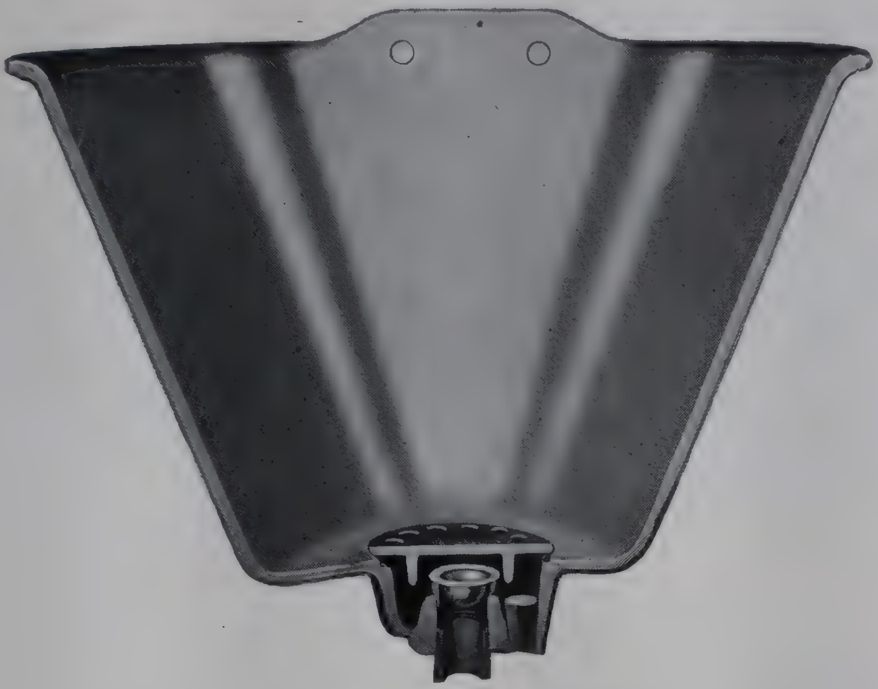
The quantity allowed per animal using drinking troughs in fields should be in the region of approximately 15 gallons per day. The advent of straw pulping plants in connection with the feeding of the herd has caused an increased demand for water and the amount necessary for straw washing purposes is in the neighbourhood of 1,500 gallons per ton of straw. If the animals are not provided with sufficient water in the cowshed, they will drink the impure water from any filthy yard puddles or from any muddy pond. As already mentioned, impure water causes contamination of the udder and will reduce the flow of milk. It also tends to taint the milk, and "ropy" milk can result from this cause.

Although adequate water supplies may be provided outside the cowshed, the supply should, wherever possible, be provided *inside the building*. The water may be obtained from a main service, which is to be preferred if such a service is available, or from a well, spring, or pond. In the case of the latter three sources, a storage tank is essential, the water being pumped into the tank as required. This tank should be provided with a cover to prevent dust and filth gaining access, and should be placed at a high level to give a sufficient head of water for all purposes. Owing to the quantity of water likely to be required daily, a large-capacity storage tank is essential, while an efficient pump is also required. The tanks should hold an ample supply, particularly in view of the experiences of many farmers during the last few years, when, owing to the prolonged drought, water had in many districts to be carried by road for long distances. A good head of water is essential, whatever the source of water supply. *Taps* should be provided for hosing down the cowshed and over such washbasins as are required for the cleansing of the milkers' hands.

The old but still popular method of watering each animal from a bucket is most unsatisfactory, nor is it advisable to use the feeding-trough for water purposes. Many producers use a *wooden metal-lined trough* extending the full length of the cowshed which is filled either by tap or automatically with water. While this method is superior to watering each animal from a bucket, in that the cows can drink as they feel inclined, the danger of the spread of tuberculosis from cow to cow offsets their utility. *Water-bowls* whose action is automatic meet the situation in an ideal fashion. As they possess many time- and labour-saving features, they have become deservedly popular with milk producers. Probably the chief reason for their popularity is the fact that their use increases the quantity of milk produced without additional expense being incurred for extra feeding-stuffs. It has been proved that, if the cows are allowed all the water they wish, their output of milk will be increased by as much as 20 per cent., and conversely, if they are allowed to go thirsty even for a short time, their production will rapidly decrease. However carefully and regularly the farmer may water his stock, his methods can never take the place of water-bowls. They are constant in action night and day, and the cow is able to get whatever quantity of water it requires. The animal is thus provided with the same freedom of drinking when stalled as when out in the fields during the summer months. Also—and this cannot be too often emphasised—where the substitution means the supplying of clean water for foul, there is far more than quantity and availability to be taken into account.

Milk contains approximately 87 per cent. of water. Apart from the water which the cow requires for milk production, it also requires several gallons per day for its own physical needs. The only way in which the cow can obtain this water constantly and regularly is by the provision of automatic water-bowls.

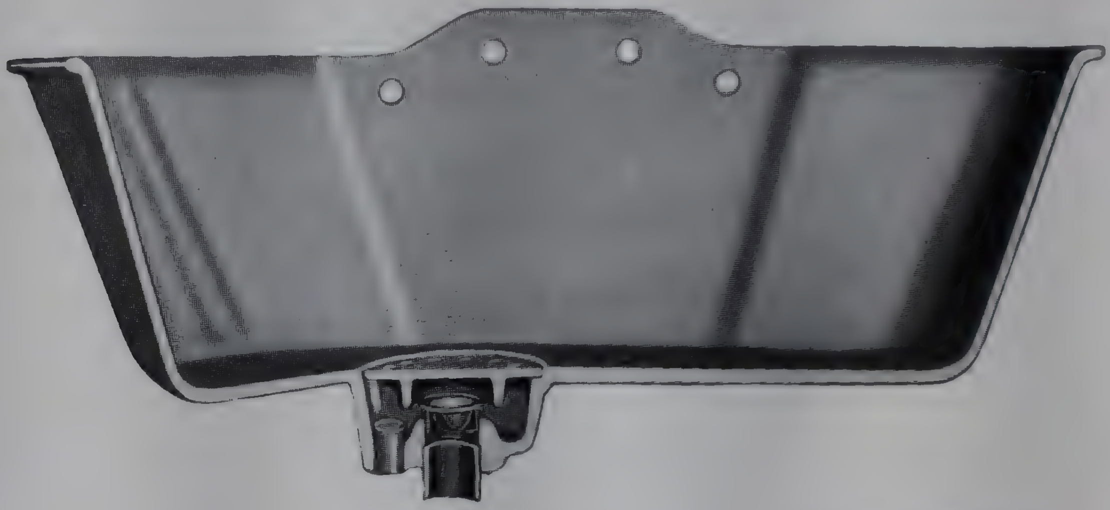
In winter it is a common practice to turn the animals out of the cowshed for a short period in order that they may satisfy their thirst by drinking from a pond or tank situated in the vicinity. It can be definitely stated that cows will not drink sufficiently of ice-cold water, so that, when this practice is carried out, many animals refuse to drink, while those which do so take insufficient for their needs. Apart from this, the drinking of ice-cold water readily causes acute forms of *gastritis* and *enteritis*. When one also remembers that the animal may become thoroughly chilled through standing in the open, the disadvantages of the system appear obvious. The provision of water-bowls thus helps to maintain the animals in good health by the elimination of unsound practices. The provision of one double bowl for each two animals, or preferably one separate bowl for each beast, is a deterrent to the spread of tuberculosis, which disease is encouraged when a common drinking-trough is used.



By courtesy of Beatty Bros., Ltd.

FIG. 45. Single-Low-pressure Water-bowl (Section).

Automatic water-bowls are of two types—low pressure and high-pressure. Fig. 45 shows a section through a low-pressure type of bowl for use with gravity feed. The dimensions are, roughly, 12 inches across by 9 inches deep, without the recess at the base. The bowl is constructed of galvanised cast-iron, and is fitted so that the base is some 12 inches above the level of the cattle standing by clipping on to the tubular uprights of the divisions. The feed tank is placed at one end of the standings, one tank being provided for each row, and it is so arranged that the level of water in the bowls is similar to that in the tank. At the bottom of the bowl is a perforated removable grid, under which is situated an aluminium valve which is lifted by the water entering the bowl On one side and below the valve is a removable rubber plug for washing out and draining the bowl. When the animal drinks, water is taken from the feed tank, which refills the bowl to the required level, the feed tank itself being replenished from the storage tank. The drainage outlet is particularly useful, as it enables the bowl to be thoroughly cleansed of all particles of food which collect in the recess. The valve responds quickly to the pressure of the water and, when the level of the water in the bowl is similar to that in the feed tank, it immediately drops back into its seating, thus preventing any back flow into the supply pipe. The depth of the bowl prevents any splashing by the animal when drinking, while the bowl itself is also devoid of any corners against which the animal may injure its mouth. The depth of water in the bowls can be regulated by bending the arm of the ball valve in the supply tank in a downward direction; this will ensure a shallower supply of water in the bowl. This is useful in the case of animals which develop a habit of splashing when drinking, as the lesser depth of water will minimise or prevent this trouble.



By courtesy of Beatty Bros., Ltd.

FIG. 46. Double Low-pressure Water-bowl (Section).

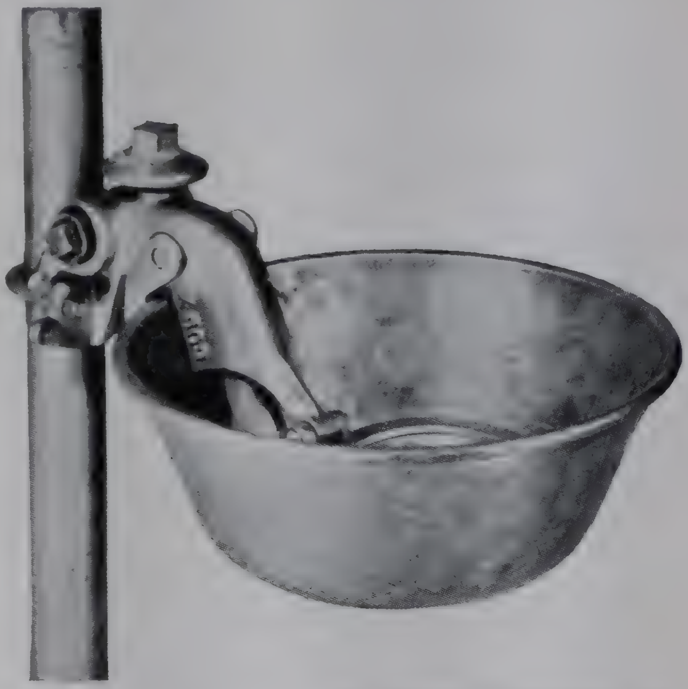
A *regulating* or *feed tank* is essential to the system. If the water supply to the feed tank is taken from a storage tank, the feed tank can be of the *low-pressure* type. *High-pressure* tanks are required when water is taken from a main service pipe. Feed tanks are best made of galvanised iron, and should be provided with covers.

A double, low-pressure bowl may be used if desired, one bowl being provided between each two animals. Fig. 46 shows a type of double bowl, the dimensions being approximately 18 inches by 8 inches in diameter and 5½ inches deep. This bowl is set with the rim 24 inches above the level of the standing, and is clipped on to the uprights.

Fig. 47 shows a common type of high-pressure bowl. It is not necessary to provide a regulating tank with this type of bowl, the supply of water being taken direct from the main service. The bowl is easily detachable for cleansing purposes. It possesses no corners, and is shallower than that of the low-pressure, gravity-feed type, having a depth of only 5 inches. Its action is quite simple. The cow in drinking presses down the pivoted toothed plate with its nose. This opens the valve, which allows water to flow into the bowl. When the animal ceases to drink and pressure on the plate is released, the valve closes and shuts off the supply of water. This bowl is economical in the use of water, and the animal soon becomes accustomed to pressing down the circular plate to obtain its supply.

When there is no main supply available and a tank filled from a well or other source of supply is used for the storage of water, it is necessary to provide a *pump*, either hand-operated or mechanically-driven. There are various types to be obtained, perhaps the most desirable being an *automatic electric* pump, which stops or starts pumping according to the pressure of water in the tank. A pump such as this would be most satisfactory, and its motive power could be obtained either from a supply manufactured on the premises or from electric power mains.

The provision of *washing accommodation* for the hands of the employees before, during, and after milking is important. Suitable *glazed stoneware lavatory basins* should be provided in accessible positions, preferably fixed to the walls at the rear of the animals if they are stalled head to head, or at the end of the cowshed if the animals are arranged tail to tail. The waste pipes from the basins should be trapped, and should discharge over trapped gullies connected to the drainage system. Water should be provided by means of branch pipes taken from the cowshed supply, and a tap should be fixed on or over each basin. A *towel* and *towel rail* should also be provided near basins.



By courtesy of Beatty Bros., Ltd.

FIG. 47. High-pressure Water-bowl.

Drainage and Disposal of Manure

It is essential that special attention should be paid to the drainage of premises in order to carry off urine and waste water from the cowshed, as well as for the removal and storage of manure away from the building.

There should be no drains or gullies inside the building. All liquid waste matters should be carried off by means of the gutters through openings in the walls at one end of the cowshed, and should discharge over *trapped gullies* connected to the drain. All gutters, if crossing any passages, should be covered with removable *steel gratings*, and small gratings should be fixed across the outlet pipes in the walls to prevent solid matter choking the gullies. The gullies may, if desired, be provided with silt buckets of some form. These have the disadvantage of wearing out and not being replaced,

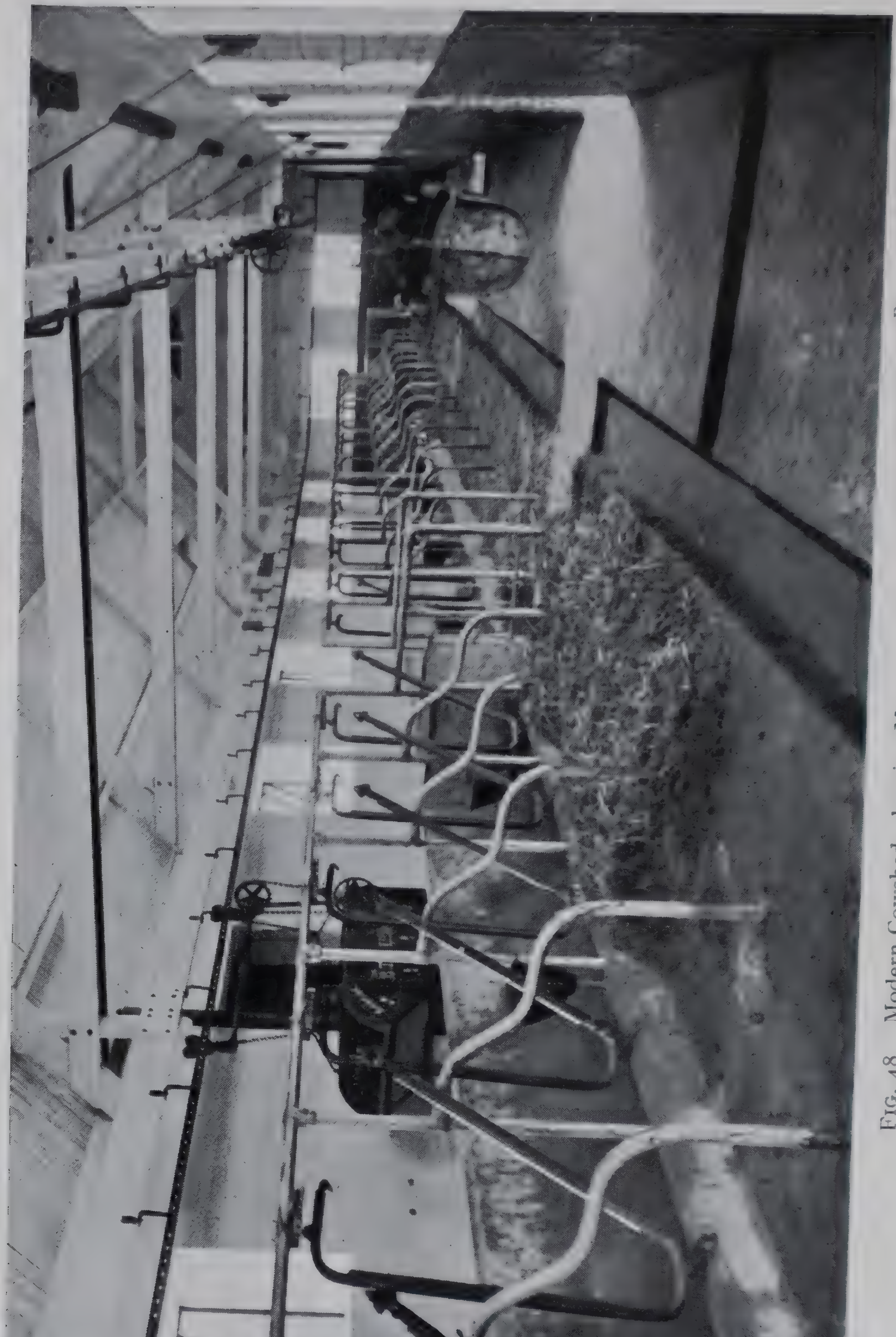


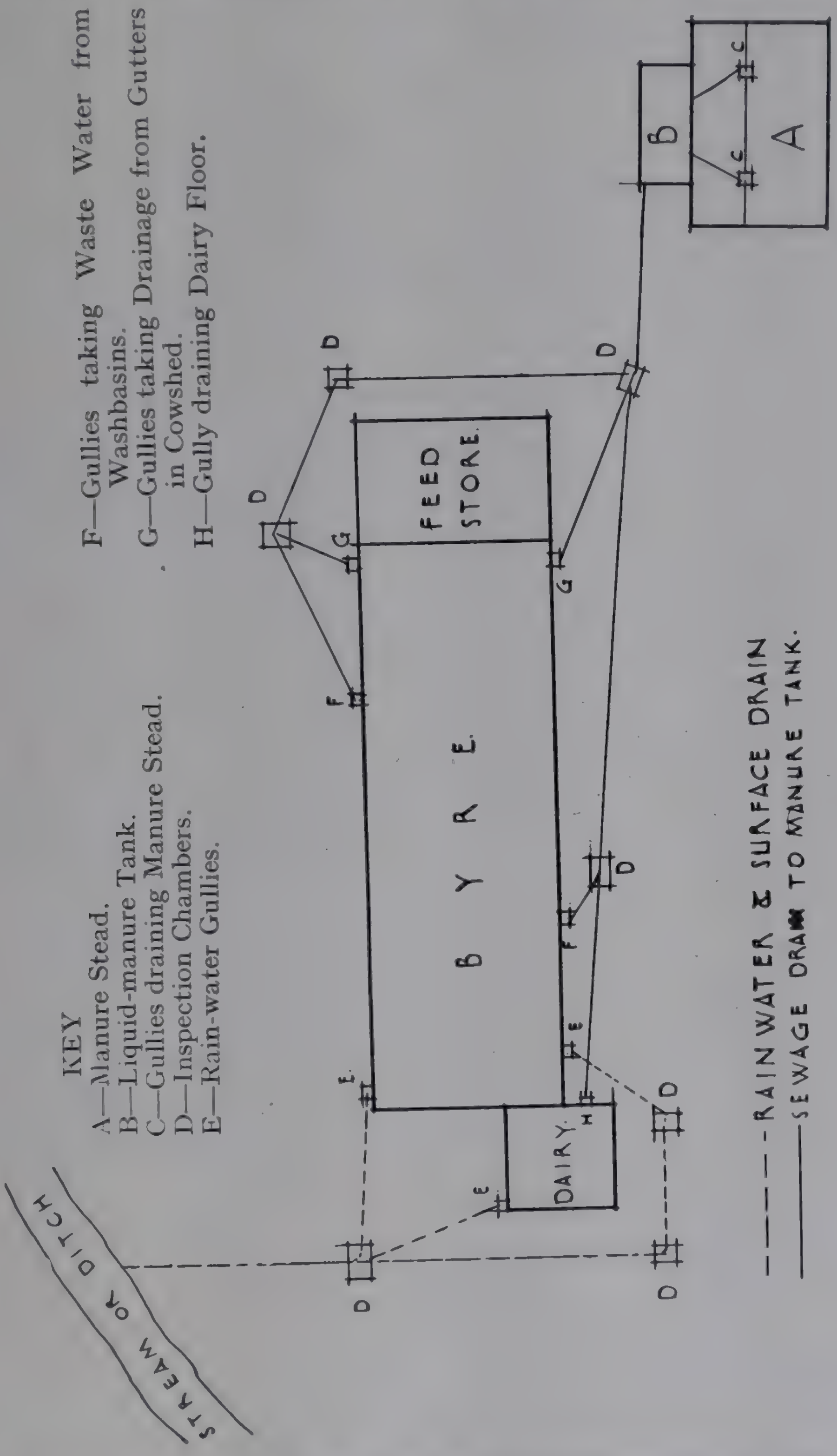
Fig. 48. Modern Cowshed, showing Manure and Fodder Carriers.

By courtesy of Beatty Bros., Ltd.

and for this reason it is preferable to have gullies with spacious interiors which will facilitate cleansing.

A new type of *twin gully*, recommended in official circles, has been designed with the object of separating floor washings from urine and manure-polluted water. A transferable stopper is provided, this stopper being intended to close either opening to the trap as required, so that floor washings may be discharged into the nearest watercourse. In this way, the value of the liquid manure would be conserved. Such a fitting is ideal in theory but in practice difficulties arise on account of neglect, misuse or damage. For this reason, the simple standard gully is to be preferred.

The drains should be constructed of *well-jointed stoneware pipes*, laid with sufficient fall, and should discharge into a *liquid-manure tank* situated at some distance from the cowshed. Means of access must be provided at all junctions and changes of direction for use in case of any stoppage.


A
B
C
D
E
F
G
H
FEED STORE
BYRE
DAIRY
STREAM OR DITCH
RAINWATER & SURFACE DRAIN
SEWAGE DRA[illegible] TO MANURE TANK.

KEY

A—Manure Stead.
B—Liquid-manure Tank.
C—Gullies draining Manure Stead.
D—Inspection Chambers.
E—Rain-water Gullies.
F—Gullies taking Waste Water from Washbasins.
G—Gullies taking Drainage from Gutters in Cowshed.
H—Gully draining Dairy Floor.

FIG. 49.

The *liquid-manure tank* should be of adequate size, constructed of concrete, and perfectly watertight. It should be covered, with means of access provided, while the provision of a chain or plunger *pump* is necessary to enable its contents to be emptied at frequent intervals. Liquid manure should be distributed over arable land while solid manure ought always to be compacted if circumstances allow as this prevents access of air and the loss of fermentable matter.

The *manure stead* should be situated near the liquid-manure tank, and should be so arranged that the drainings from it are carried into the tank. It is also advisable to roof the manure stead in order to protect its contents from the action of the sun and rain.

The manure should be removed from the cowshed twice daily and taken direct to the manure stead. Hand trucks or barrows may be used for this purpose, or, if the passages are sufficiently wide, a cart can be driven through the cowshed for the collection and removal of manure. For large cowsheds, a bucket of suitable size running on wheels, or on an overhead track should be installed. This will be found to be an extremely labour-saving device, as the manure is removed easily and directly to the manure stead. Indeed, the ideal system is a cart kept standing near the cowshed into which all manure should be placed, to be removed once daily and taken direct on to the land. This method avoids the cost of erecting a manure stead and saves considerable time and labour, besides providing for complete removal of manure away from the farm buildings.

It is vitally necessary to have the manure stead at a reasonable distance, at least 50 feet, from the cowshed, not only as a safeguard against any nuisance from smells, but also as a preventive measure against the greater nuisance of flies. The manure forms an ideal breeding-ground for these insects which may easily become a serious menace and hindrance to clean milk production. They breed rapidly under the suitable conditions found on manure heaps, but happily possess a limited range of flight. Thus, if the manure is situated some distance from the cowshed, the number of flies obtaining entrance to the premises will be considerably reduced. This distance is, of course, limited for economic reasons, but a minimum of 50 feet should be adhered to and a greater distance obtained wherever possible.

The National Institute for Research in Dairying, Reading, has carried out some valuable experiments in observing contamination by flies. Mattick gives the following information regarding these experiments :

No.	No. of Bacteria per 1 ml.	B. coli.	Keeping Properties at 60° F. Hours.	Remarks.
1	4,300	†	96	Clean milk in sterile bottles.
2	6,300	†	96	Clean milk in sterile bottes.
3	2,500	†	96	Clean milk in sterile bottles.
4	13,700	†	84	Clean milk put in a sterile bottle in which a single fly had been allowed to crawl.
5	20,800	*	48	
6	34,000	*	48	

* = B. coli in $\frac{1}{10}$ ml.
† = B. coli absent in 1 ml.

These results are illuminating, and from this it will be seen that all possible steps should be taken to exclude these objectionable insects from every place in which milk is produced or handled.

In the block plan shown in Fig. 49, the drains and the position of the liquid-manure tank and manure stead are shown.

Eaves gutters, preferably of metal, must be provided to the cowshed roof to carry off the rain-water by means of suitable downpipes. If no gutters are provided, the rain-water splashes on the walls, causing the building to be cold and damp and proving very destructive to the fabric. This rain-water should under no circumstances be allowed to enter the liquid-manure tank. It should be carried away to the nearest watercourse by a separate system of drains. It is not essential to provide gullies at the foot of rain-water pipes, but *gratings* should be placed in those positions to prevent the access of rats from the drains.

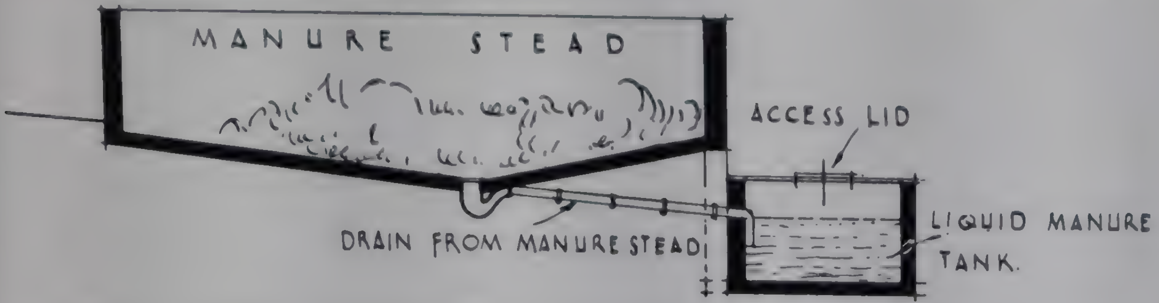


FIG. 50. Section through a Manure Stead and Liquid-manure Tank.

MILKING SHEDS

It is not essential that a separate shed for milking purposes only should be provided. Many hundreds of farmers produce the cleanest of milk without any other structure than that of the cowshed. If its construction is possible, however, and the money available, such a shed is certainly to be recommended, as by its aid the labour of cleaning the animals is greatly reduced and the production of clean milk definitely facilitated.

The construction of a milking shed follows closely the general lines laid down earlier in this chapter for the building of cowsheds. It is not, however, necessary to have such an elaborate building. The usual type of steel or wood-framed building, covered with asbestos sheeting and with a lean-to roof composed of similar material, is quite sufficient for the purpose, although a more permanently constructed building is generally to be preferred. It should be stressed that the extra expense of such a permanent structure should never be allowed to stand in the way of providing a milking shed, as the cheaper type of building serves the purpose quite admirably. Its size depends upon the number of animals which the herd contains, but if it is sufficiently roomy to house approximately one-third of the total number of animals at one time, it can be considered large enough for its purpose.

The building should be of sufficient capacity to provide each animal with 600 cubic feet of air space. This cubic capacity is ample when one remembers that the shed is only used for milking purposes. The ventilation inlets and outlets should be similar to those provided for cowsheds, except that the outlets in the roof need not be so elaborate. Some rearrangement of the ridge tiles to provide sufficient outlets will usually be found quite satisfactory.

The floors should always be of concrete, preferably with a carborundum finish and, although it is not essential that the standings should be raised above the floor-level, this is certainly advisable, a depth of 6 inches being ample. In either case there should be a slight fall to a drainage channel provided to carry off waste water.

A manger of a similar type and height to that required in a cowshed should be provided, except that the width need not exceed 1 foot 6 inches. A simple channel such as a half-round, well-glazed pipe serves very well for this purpose. Although it may not be advisable to supply food-stuffs prior to milking, it is a well-known fact that the animals stand quieter during the process of milking when given some food to claim their attention Such food should be dustless—for instance, cake or other concentrates.

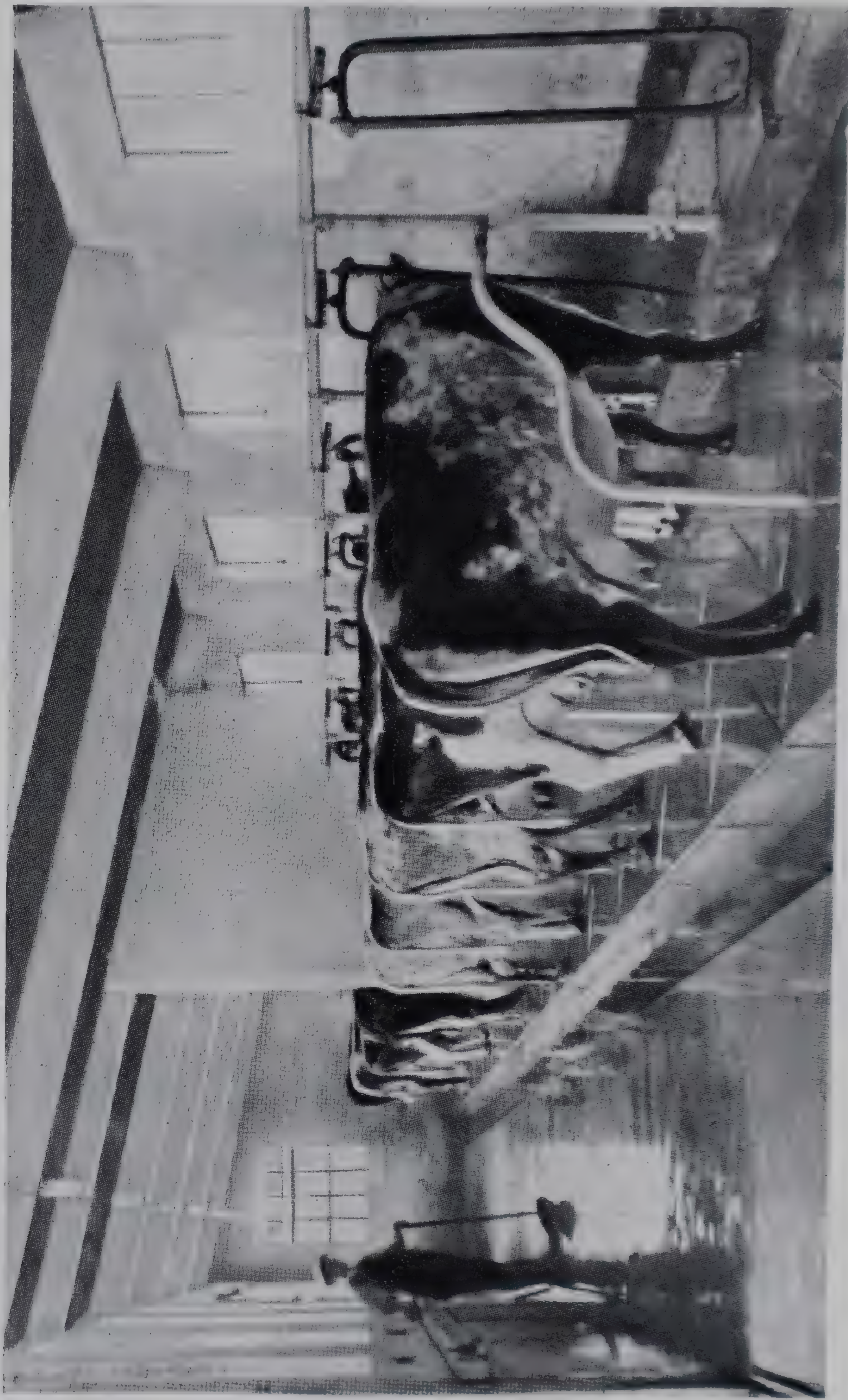


FIG. 51. Milking Shed, National Institute for Research in Dairying, Reading.

By courtesy of Beatty Bros., Ltd.

Divisions or yokes should be similar to those outlined for cowsheds, but ground space may not permit of a feeding passage being provided. This is not essential, and should not be provided if the site is of insufficient width to allow both a feeding passage and a wide passage at the rear of the animals, the wide passage for removing milk and dung being greatly to be preferred in such a case.

The building should be so built as to obtain the maximum amount of natural light, and care must be taken to ensure that this light falls on the hindquarters of the animal. Windows over the feeding-trough at the head of the animal are not necessary, but ample artificial light must always be provided.

Drinking bowls are not essential, but an ample supply of pure water should be provided, preferably by means of a tap, both for washing the animals and, with a hose pipe, the floor of the shed. Provision must also be made for washing the hands of the milkers both prior to and during milking operations.

The approach to the milking shed from the cowshed should be covered, if possible, although this is not essential. It is more important to ensure that the approaches to the shed are properly paved and kept clean under all weather conditions, so that the animals do not tramp through manure and other filth before entering the shed. If possible, the building should be so arranged that the animals enter at one end and leave at the other, thus avoiding confusion between outgoing and incoming animals. The shed should be built abutting on or adjacent to the dairy or milkroom. As the animals are only in the shed for a brief period during milking, no bedding will be necessary, although a little straw in the gutter tends to prevent any splashing of urine or excrement discharged by the animals. As in the cowshed, all corners should be rounded off and the gutters should discharge over the usual type of gully connected to the drainage system.

Many producers will no doubt declare that a milking shed is a luxury. This may be so, but it is one of those luxuries which should only be foregone in cases of financial stringency. No one can deny that its provision and proper use prove a very definite aid to clean milk production.

RECONSTRUCTION

Producers are not always able to erect new buildings in the manner already described, although this is undoubtedly the ideal procedure. Reconstruction work therefore becomes an extremely important consideration.

In different parts of the country many buildings are to be found in use as cowsheds which are in need of reconstruction to a varying degree, and it must be stated that many existing buildings ought to be treated as insanitary property, and demolished. When cow-keeping as a means of milk production was in its infancy, these buildings were erected and used for a variety of purposes. As the demand for milk grew and its sale increased, so were these various types of buildings converted into cowhouses, often in an unsatisfactory manner and without due provision for the future. The best methods of conversion were rarely considered, the only point at issue being the speed at which the buildings might be transformed into a profit-yielding asset. The result now is that many farmers have been saddled with a legacy of the past, a legacy which they discovered was a liability and not an asset when the Milk and Dairies

Order came into being. There are too many of these cowsheds still in their original unsatisfactory condition, and recently even more have been added to the number. The remunerative price to be obtained for liquid milk at the present time has caused numbers of cowkeepers who formerly produced milk for manufacturing purposes only to sell their milk for direct human consumption. In many cases, if not in the majority of instances, the cowsheds of these producers are entirely unsatisfactory and their methods even more so. More than that, there are few cowsheds in existence which could not be improved in some way or another, while more are in need of complete reconstruction, but care should be taken to prevent any extension in the use of small buildings or additions to buildings which are badly sited. Finally, there are a number of cowsheds which, having been reconstructed years ago, are once again in need of further alterations from the point of view of easy working and sanitary condition.

One might advance several reasons as to why the necessary reconstruction work has not been carried out, chief among these being financial inability, expectation of notices from the local Sanitary Authority, and changes in ownership or tenancy of farms. It will be readily recognised that such reasons are entirely inadequate to excuse errors of omission in dealing with such a vital matter as reconstruction. Further, under Defence Regulation 62, powers are given to War Agricultural Executive Committees to deal with producers who refuse to carry out the necessary works required to bring their cowsheds into line with modern requirements.

The reconstruction of an old cowshed undoubtedly presents many difficulties. It is a comparatively easy task to plan and design a new building, given a satisfactory site and sufficient capital, but with old or existing buildings one is often confronted with the problem of how to make the best of a bad job. Whilst reconstruction may render a building more satisfactory than previously, it may not be possible, however adequate the intention, to render the reconstructed building equal to a new cowshed. Therefore, before any reconstruction scheme is begun, the cost of the work required should be closely compared with that of erecting a new cowshed of similar or greater size. If, on comparison, it is found that the cost of a new building is even slightly more than that of reconstructing the old one, a discovery which is often made, the alterations should in all cases be discarded in favour of starting afresh.

Happily for the producer, it is in many cases quite an easy matter to carry out reconstruction work at a moderate cost, but certain items are indispensable if satisfactory results are to be obtained. In order of their importance these are:

(1) *Floors.* Must be impervious and well drained (see page 94).

(2) *Lighting.* Both natural and artificial lighting require the strictest attention (see pages 90–91).

(3) *Passages.* The provision of a passage between the walls and the animals should receive serious consideration (see page 83).

(4) *Manure Stead.* Proper storage of the manure away from the shed is indispensable (see page 109).

In quite a number of instances small alterations only are required. These may consist of alterations to the standings or floor, the provision of a satisfactory gutter, the removal of wooden divisions and their substitution by a more suitable device, or merely slight improvements to the lighting and ventilation.

The *site* of an existing building is often found to be entirely out of conformity with modern ideas. In many instances, cowsheds were built with entrances from manure or stockyards, having in addition the wrong aspect to obtain maximum light through being hemmed in by buildings.

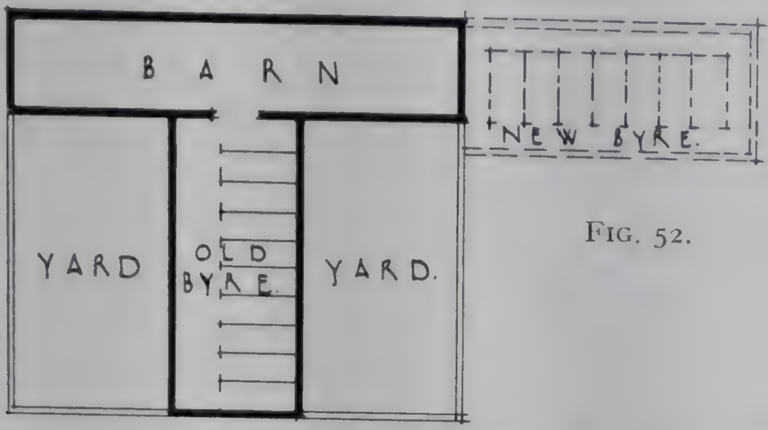
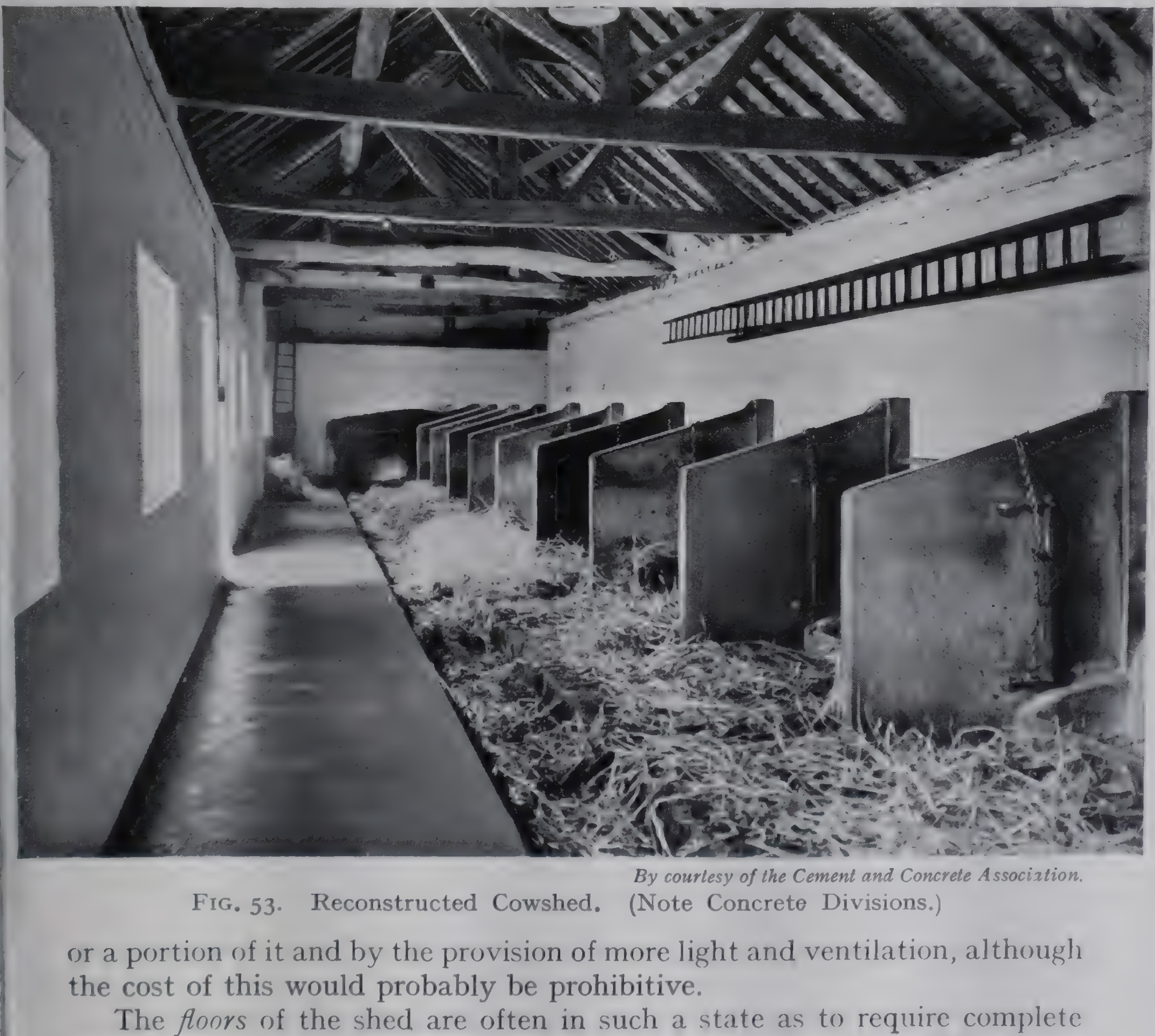


FIG. 52.

Such a shed is illustrated in Fig. 52. Probably the best method of dealing with this type of premises would be to erect a new building on the site shown. Much could also be done to improve the yard by paving either the whole or a portion of it and by the provision of more light and ventilation, although the cost of this would probably be prohibitive.



By courtesy of the Cement and Concrete Association.

FIG. 53. Reconstructed Cowshed. (Note Concrete Divisions.)

The *floors* of the shed are often in such a state as to require complete reconstruction, this being commonly the most expensive item of the reconstruction scheme. The type of material found in old buildings is seldom impervious to moisture, the standings are too long, and insufficient room is left behind the animals for the milking and dunging passage. In this case the entire floor should be taken out and the whole replanned and relaid on an up-to-date basis, within the limits prescribed by the size of the building.

The question of *air space* in an old cowshed often gives rise to difficulties. As 600 to 800 cubic feet per head should be allowed according to the type of animals in the herd, it may be found that the cowshed is not large enough to accommodate all the animals which use it. It would then be necessary to accommodate as many animals as the air space allowed in the reconstructed cowshed, and to build a new shed to house the remainder. The surplus animals could, of course, be housed in any building which was also capable of reconstruction and was of suitable size.

Improvement in the *ventilation* of an old building is one of the simplest alterations called for. Attention to the ridge tiles with a view to providing more efficient outlets, and the addition of more hopper-type windows and extra inlets, will usually provide the cowshed with all the additional ventilation required. Any of the existing inlets which allow a direct current of air to fall on the animals should be abolished and a more satisfactory type installed.

It may be necessary, through force of circumstances, to increase the height of the *roof* in order to give sufficient air space. A new roof can easily be provided by the use of light roof timbers, steel or asbestos trusses covered with corrugated asbestos sheeting. Existing roofs may be materially improved by casing in with match-boarding or ceiling board. This is particularly useful in the case of thatched roofs, which, although satisfactory *per se*, are unsatisfatory from the point of view of clean milk production (see page 93).

The provision of additional *windows* will increase the natural light entering the cowshed. The provision of more roof light will also attain this object. This type of light is very valuable, and can be obtained by replacing some of the existing roofing tiles with *glass tiles*, a simple and inexpensive operation ; or by the more expensive method of providing suitable skylights. Difficulties may arise in providing more windows in the walls, but such difficulties can easily be overcome by attention to the points outlined. The *glazing of the upper halves of the doors* will also assist in providing additional natural light.

Walls seldom require much alteration. The lack of cement rendering is the most prevalent fault, particularly in many of the older cowsheds constructed of rubble or undressed stone. It may be found advantageous to rebuild one wall in order to give increased width and air space. In the southern and western counties, certain other difficulties may be experienced. In the majority of cases cowsheds already in existence and certainly those in need of alteration will be found to be single-range erections without any external wall at the rear of the animals, as, on account of the more favourable weather conditions experienced, the building is left open, one side of the roof being supported on piers. Even when some form of partition is erected at the rear of the animals, this is usually of wood and is generally unsatisfactory, usually due to its close proximity to the animals and the ease in which it quickly becomes coated with filth. In all such cases, the structure should be extended so that the passage at the rear of the animals is of sufficient width If this is done and some protection from the weather is still required, it can be provided by means of a 4½ feet brick, stone, or concrete wall suitably rendered in cement and sand to facilitate easy cleansing.

The *gutters* may be, and often are, too shallow. Provided that the floor and the standings are otherwise satisfactory, this difficulty is easily overcome, either by renewing the gutter entirely or by increasing its depth. If there are no gutters already in the cowshed, these should be provided.

Wooden divisions are all too common in old cowsheds and should always be removed. Although concrete divisions, which are cheap and durable, may be considered an improvement, consideration should be given to the question of providing the more satisfactory tubular divisions and yokes. If this expense is too great, *bent iron pipes* may be used as divisions. These latter are entirely satisfactory, and should be used in preference to concrete. Above all, wood must be abolished at all costs.

With regard to the method by which the animals are secured, *tubular yokes* should be provided in all reconstruction schemes, as they are the only satisfactory method of meeting this requirement.

The *water supply* of old cowsheds is seldom entirely adequate. How often does one see a cowshed in which between 30 and 40 cows are housed, with one tap from which all water has to be carried to the animals in buckets ? Sometimes not even this is found. Instead, water may have to be carried, summer and winter alike, from some trough or pond situated a considerable distance from the cowshed, and then only when the owner feels so inclined. It is admitted that a tap fixed in the cowshed is better than the latter method, but this is not enough. Every effort should be made to provide water-bowls as already described (see page 104). The provision of a storage tank is sometimes also necessary, as part of the reconstruction work. The water supply is not an alteration or improvement upon which economy should be practised. As previously stated—and this cannot be emphasised too often—water in quantities is essential for the well-being of the animals and for increased milk production. Indeed, without its aid the production of clean milk becomes exceedingly difficult, if not impossible.

Some *washing accommodation* for the milkers is also necessary. Whilst a proper wash-basin is desirable, expense may be saved by the provision of a suitable alternative such as a metal or wooden stand holding an enamel basin with, over it, a tap. Failing this, a jug of water should be placed underneath the stand. Soap, towels, and towel holders should also be included.

In many cowsheds the *gutters* drain to the adjoining yard, and here liquid manure mixes with the solid manure stacked near the cowshed, thus forming a veritable quagmire of filth. Drainage is often expensive, but it is an essential alteration. The existing *manure stead*, if near the cowshed, should also be removed to a suitable distance.

Reconstruction work raises many difficulties, but if common sense and a broad outlook are brought to bear upon the various problems as they arise, there can be no doubt that the healthier stock, cleaner milk, and economy in labour which invariably result will well repay the owner's trouble and expense. One often meets the producer who states that any alteration of his present cowshed is unnecessary, as he is producing milk equal to the "Accredited" grade in quality with the shed in its present condition. This may be so, but one can never say how long these conditions will continue, while, as stated, a satisfactory building is invariably an ultimate economy. It enables the employees to work under decent conditions, a fact which they quickly appreciate ; the health of the animals is improved, and the task of cleaning and maintaining them in a satisfactory condition is rendered simpler and less costly—economies which are likely to move all but the most stubborn producer.

FIG. 54 shows a cowshed following the first stage of reconstruction. The conditions found in this cowshed before the alterations commenced were deplorable. The width of the building prevented the provision of feeding passages. The owner had only a limited amount to spend and, as the photograph shows, the floor and divisions first received attention. Hopper windows were subsequently placed in the side walls and the ventilation openings blocked.

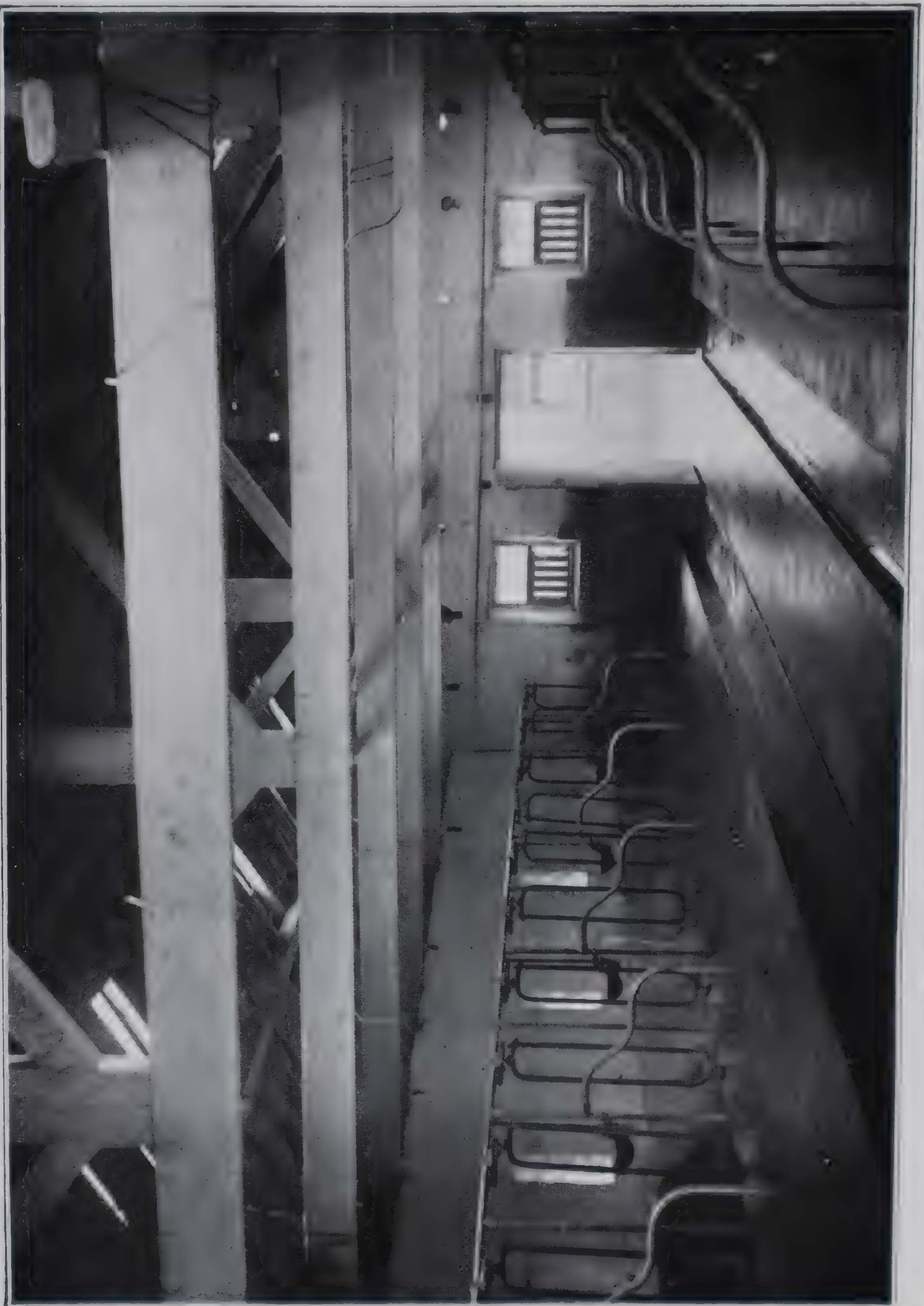


FIG. 54. An old Cowshed. (First stage of Reconstruction.)

By courtesy of the Newburn U.D.C.

COWSHED INSPECTION

The principle underlying cowshed inspections which should always be borne in mind, is that such visits are made with three objects in view, as follows :

(1) The protection of the community by safeguarding the production of an essential food.
(2) The provision of a reasonable standard of sanitation in the cowshed.
(3) The stressing of the simple, inexpensive yet vital principles of cleanliness in methods of production.

For many years there has been a serious lack of uniformity of inspection throughout the country. This irregularity is particularly to be deplored, since it has been the means of causing intense dissatisfaction amongst producers, especially in adjoining districts. This lack of uniformity is due to the following causes :

(1) Want of interest on the part of the officials concerned.
(2) The impossibility of properly supervising the production of milk, especially in rural areas, owing to the number of producers and the inadequacy of the available staff.
(3) Lack of knowledge of the principles *and* practice of clean milk production with a consequent inability to meet the farmer on his own ground. Only some 50 per cent. of the Sanitary Inspectors of this country have attended clean-milk courses, and many of those are not intimately concerned with the production of milk.
(4) The absence in all milk legislation of any definite guiding principles which would help to secure uniformity in various districts. It is admitted that the legislation in force might be more fully utilised than is the case at present, but no comparative standards as regards such vital matters as lighting and ventilation are given for the official's guidance.
(5) A deplorable lack of interest and support given by many Councils to the officers concerned. It is hardly necessary to state that no official can give of his best unless fully and wholeheartedly supported by his Council.

There are two types of producers with which officials have to deal :

(1) The Type which is amenable to reason

This category includes those producers who are prepared to learn new methods, always provided that such new ideas are better than those which they happen to be using at the time. They are men with open minds, alert and ready to move with the times and willing to provide modern facilities to meet modern requirements. This type of producer can be dealt with easily and simply by *education*, and the inspection of their premises should be carried out with this pioneer idea in mind. It is not necessary to bring legal fulminations to bear upon them, nor to treat them as law-breakers because of any trifling peccadillo which they may have committed. Indeed, it will probably be found that there is no producer who has not broken the law in some minor detail, either through ignorance or want of thought. It is always advisable to make suggestions to such producers concerning new methods, but it is essential that these suggestions should in every case be accompanied by the logical reasons which have prompted them.

(2) The Type which is not amenable to reason

This type is represented by those producers who will not move with the times and who are indifferent to progress, preferring the crude methods of their forefathers to the modern dictates of hygiene. There are still far too many of this type producing milk, greatly to the detriment of the good and careful producer. There is only one way of dealing with such persons, and that is by compulsion, as their mentality does not unfortunately allow them to understand the value of progressive educational measures. It should always be remembered that, quite apart from any ethical considerations, the interest of the milk trade itself demands the immediate abolition of this class of producer.

The cowshed in charge of a careful producer has an atmosphere of its own, and a person making an inspection of such premises will quickly realise this fact. Certain phenomena are immediately impressed upon the senses of anyone entering such a cowshed, namely :

(1) *The absence of any offensive odour.* The fœtid atmosphere so noticeable in certain cowsheds may be due to the food given to the animals, the want of proper cleansing of the floors, or the absence of adequate ventilation. If these points receive proper attention there should be no objectionable odours.

(2) *The light and airy appearance of the building.* The appearance of the walls and ceiling will certainly suggest regular limewashing, *not* carried out merely in accordance with legal requirements, but as often as is necessary.

(3) *The absence of food scraps in the mangers.*

(4) *The healthy, contented appearance of the animals.*

To sum up, more satisfactory results can usually be obtained by tact and common sense than by the use of the various Acts and Orders issued. It always pays the official to work *with* the farmer rather than *against* him, in so far as circumstances will permit. If the administration is fair and just, the official will be welcome on the farm, and the farmer will readily listen to the advice tendered. Producers should be dealt with in such a manner that they look upon the official as a friend and adviser rather than as someone who periodically calls upon them merely to demonstrate the power of the law. On the other hand, no quarter should be given to the wilful law-breakers who are an ever-present menace to the safety of the nation. For such persons, the strict administration of the penalty clauses provided by the various Acts and Orders is necessary. Farming is, on the whole, a difficult calling, and the producer has many serious problems to face. If the necessary help and advice are provided, better results are almost certain to follow.

CHAPTER V

THE DAIRY

General

THE previous chapter dealt with the cowshed in all its aspects, it being pointed out that, by proper construction and sanitation, the production of clean milk will be encouraged. To ensure that the milk remains in this condition, very careful attention is demanded, not only as regards storage after production, but also as regards the sterilisation and storage of the utensils used and their protection from contamination. It is in this connection that the dairy and its allied buildings play a prominent, indeed a vital, part in milk production.

The need for a suitably placed and properly constructed dairy building on all farms is not yet sufficiently realised by the milk producer. Reliance is too often placed upon the farm kitchen situated at some distance from the cowshed, while occasionally the milk is stored in any building, however ancient and unsuitable, adjoining the cowshed. To make matters worse, the milk store is too often an old shed serving the dual purpose of dairy and general store. The conditions found in such places of storage are often deplorable, and provide an almost certain source of contamination. Cleansing of utensils and even of clothing is carried out in the same room as that in which the milk is stored, while the water required for washing the churns and other utensils is heated in the copper used for the dirty linen. It is to be regretted that premises used in this way are by no means uncommon, nor is it to be wondered that contamination follows.

There appears to be a peculiar absence of reasoning on the part of some producers concerning the provision of a proper dairy. A farmer will spend a large sum of money on his stock and cowshed, but becomes most parsimonious when called upon to provide suitable dairy accommodation. The argument generally used is that, since the milk is almost immediately removed from the farm or is delivered daily to the customer, no proper dairy is required. The fallacy of such so-called logic can be easily seen when it is remembered that the evening milk has often to stand overnight until delivered the following morning, during which time it rapidly becomes contaminated and even curdles. The annual losses to the milk industry in this way are very large and, quite apart from the unhygienic principles which they represent, are definitely unnecessary. If milk is produced under strict hygienic conditions, souring can only be due to improper treatment after production or want of proper sterilisation of the utensils. There is obviously no sense in a policy which expends money, often liberally, with a view to improving conditions of production only to waste it needlessly in another direction. In short, the farmer must be impressed with the necessity, not only for producing clean milk, but for storing it under suitable conditions.

Site

It has already been demonstrated that the cowshed must have a carefully chosen site, and this principle applies with equal force to the dairy. For practical reasons the choice of site should fall upon a position in close proximity to the cowshed. This may be obtained in one of two ways. The dairy may be either a part or continuation of the same building, or it may be housed in an adjacent but separate structure. If the first alternative holds, there must be no direct entrance from the cowshed, and the dividing wall should be perfectly dustproof. The milk in this case could be poured into a covered receiving tank situated on the wall adjoining the dairy, from which it could be run by means of a removable pipe through the wall into the milk room, where it could then be discharged over the cooler. The provision of a collecting tank *outside* the dairy is always to be recommended, as then the milkers need not enter the dairy from the cowshed.

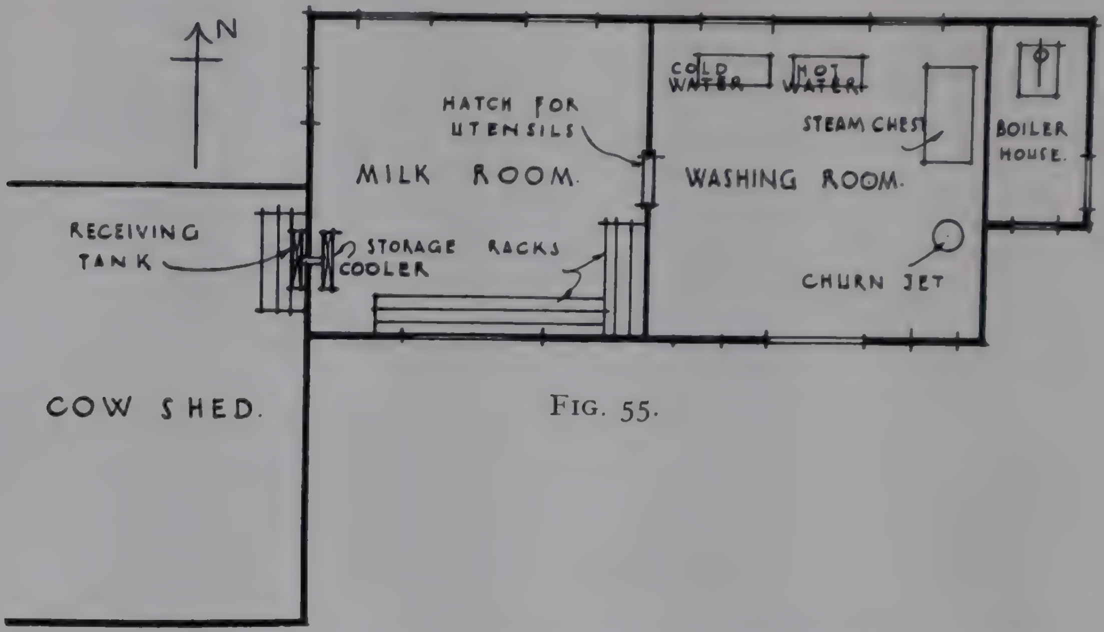

N
HATCH FOR UTENSILS
MILK ROOM
COLD WATER
HOT WATER
STEAM CHEST
BOILER HOUSE
WASHING ROOM
RECEIVING TANK
STORAGE RACKS
COOLER
CHURN JET
COW SHED

Fig. 55.

It is not always possible for the dairy to be built as part of the cowshed building, and in this case the second alternative must be chosen. When this situation exists, the dairy should be constructed as close to the cowshed as possible, so that milk can be quickly removed thereto without undue risk of contamination. Close proximity to any likely source of contamination, such as the manure heap or stackyard, should be carefully avoided.

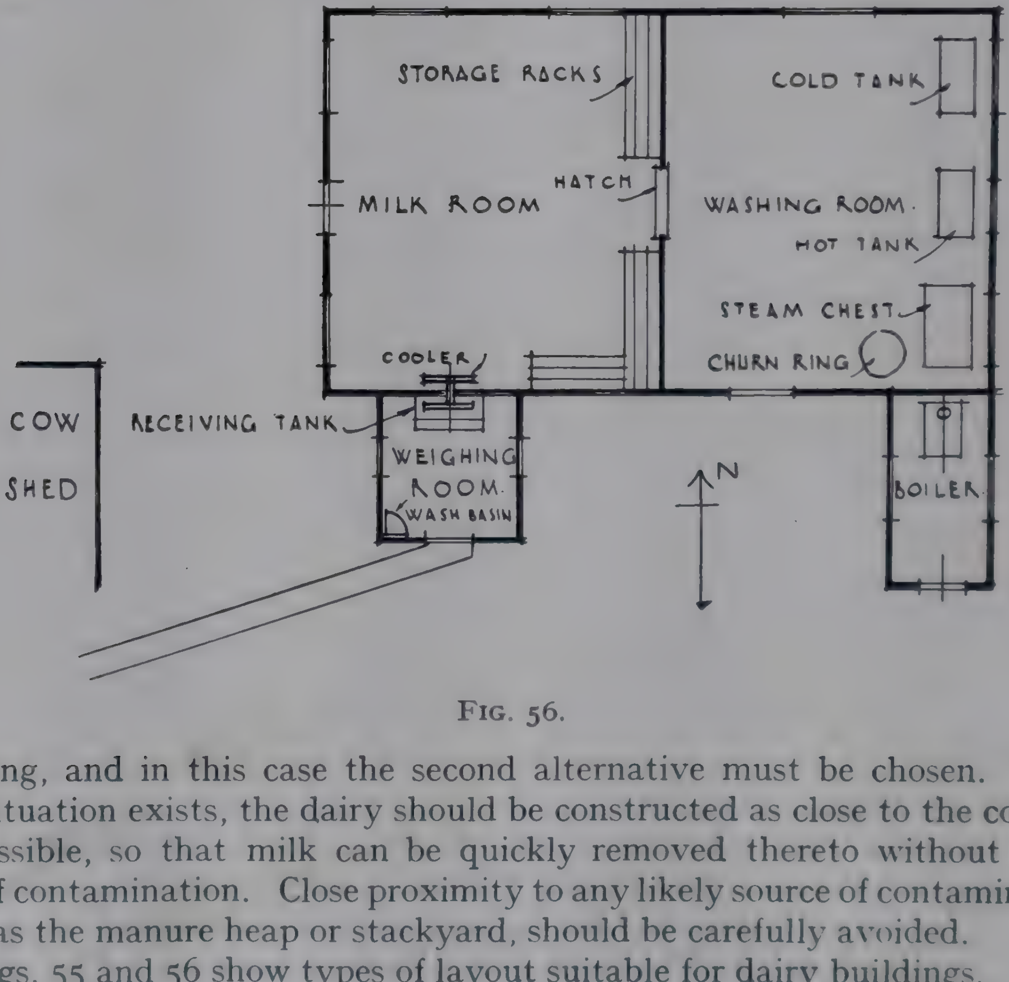

STORAGE RACKS
COLD TANK
HATCH
MILK ROOM
WASHING ROOM
HOT TANK
STEAM CHEST
COOLER
CHURN RING
COW SHED
RECEIVING TANK
WEIGHING ROOM
WASH BASIN
N
BOILER

Fig. 56.

Figs. 55 and 56 show types of layout suitable for dairy buildings.

The dairy building should be preferably divided into three separate parts or sections, as follows :

(1) The weighing room, in which the receiving tank for the milk is situated.
(2) The milk room.
(3) The washing and sterilising room.

If a steam sterilising plant is provided, the boiler should be adjacent to, but not situated in, the washing room. It is frequently found that the utensils are washed and stored in the room where the milk is cooled, bottled, and stored. This should never be the case, as it is essential to have an entirely separate milk room.

The *size* of the dairy depends upon the quantity of milk produced at the farm. A large turnover naturally demands appropriate floor space, but it is always advisable to have the maximum amount of room available in order to give adequate working space, not only for the sake of convenience, but also as an aid to cleanliness. The *aspect* of the dairy should be such that all the main windows of the milk room face in a northerly direction, thus providing light without strong sunlight. A cool dairy is essential, and all windows facing in a direction which permits of strong sunlight gaining access to the milk room should be glazed with tinted glass to prevent excessive heating of the room.

The dairy buildings, whether or not they form an integral part of the cowshed, should be constructed either of *brick, stone, or concrete.* The roof should consist of some material which insulates the building and so prevents excessive heat in summer. *Tiles, slates, or corrugated asbestos sheeting* are entirely satisfactory, but *corrugated galvanised iron* should never be used as this attracts heat. No other materials are so satisfactory as those mentioned above.

As a large amount of water is required for a variety of purposes, it is essential that an adequate *pure water supply* should be provided. Taps should be fixed at all essential points, and a storage cistern should also be provided for any existing boiler.

With regard to the separate portions of the building, the following details are of importance.

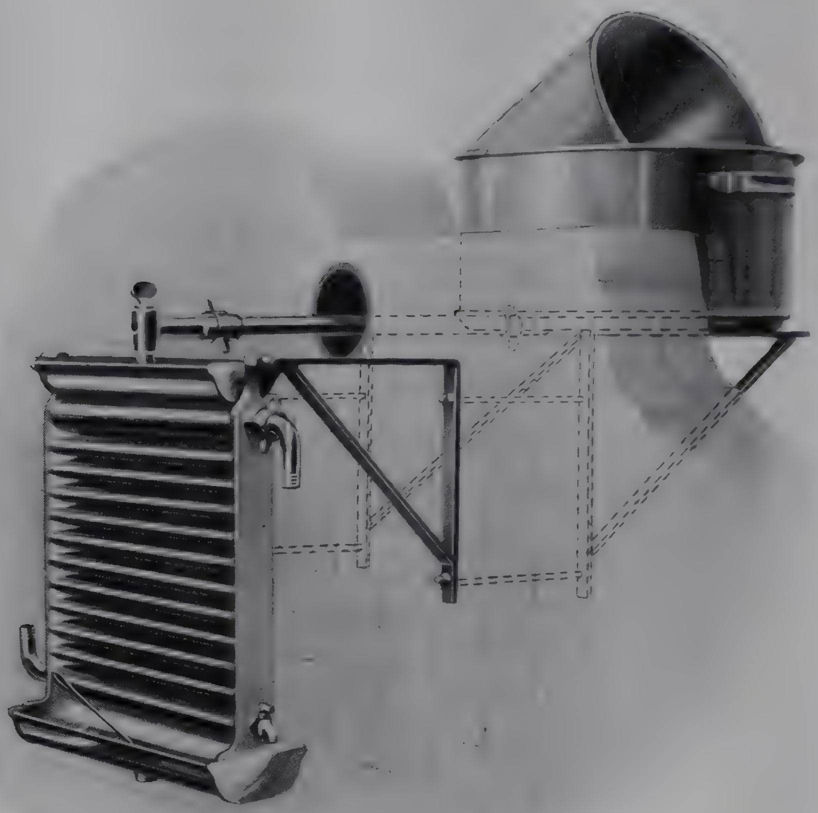
The Weighing Room

The advantages to be derived from a separate weighing room in which the milk-receiving tank may be fixed are obvious, while the advantages to be obtained from weighing the milk have already been enumerated (see page 52).

There can be little doubt that the best place in which to weigh milk is a room adjoining the dairy, although this is only possible where a separate dairy building is provided. The room need not be very large, but should allow the receiving tank for the milk to be fitted where it will be out of range of possible contamination from the air of the cowshed. If this is done, milk can be removed from the cowshed immediately it is produced to the weighing room, where it is weighed and the weight recorded, after which it can be poured into the receiving tank, whence it passes by gravity to the cooler. The room can also be used for the storage of milkers' overalls but it should not be allowed to become a dumping-ground for all types of rubbish. A lavatory basin with water supply and clean towels adjacent should be provided in one corner.

It is the practice on some farms to place the *receiving pan* outside the milk room, either in the open air or under a lean-to roof. Such an arrangement is quite satisfactory, since it prevents milkers bringing full pails from the cowshed into the milk room proper. As the receiving tank is placed at a higher level than can be comfortably reached from the floor, owing to milk having to gravitate through the cooler, a platform with steps is necessary.

The floor of the weighing room should be of *concrete,* draining to a trapped gully outside the building. This should be washed down twice daily. The *walls* should be rendered with cement up to a height of 4 feet 6 inches, and that portion of the wall above the rendering should be limewashed as often as required. The expenditure of a large amount of money on lining the internal surface of the walls with tiles or glazed bricks is unnecessary.



By courtesy of Aveling-Barford, Ltd.

FIG. 57. Receiving Pan with Anti-splash Cover and Cooler.

Fig. 57 shows the arrangement of the receiving tank and cooler fixed on the dividing wall between cowshed and milk room. The *receiving pan* shown has a fixed dome, and the open portion may be fitted with a hinged cover so that the inside of the receiver is only open to the possibility of contamination from the atmosphere during the few seconds in which the milk is being tipped into it. A *pipe-line filter*, fixed as shown in Fig. 94 (page 176), is desirable and to be preferred to an open strainer, but, if it is not intended to strain milk until after cooling, the arrangement shown in Fig. 57 is quite satisfactory. The receiver may also be situated in the weighing room. This arrangement is to be preferred, as there is not so great a risk of contamination from the air of the weighing room as there is likely to be in the cowshed.

The Milk Room

As the milk room, if properly designed and built, is a valuable aid to clean milk production, any money expended on its construction will be amply repaid.

The internal surface of the walls should be rendered with cement to a height of 4 feet 6 inches, and the upper portion should be limewashed either direct on to the brickwork or on to a roughened rendering of *cement*. The rendering should be carried up to the full height of the room behind the cooler, and this should *not* be limewashed. An excellent and clean-looking internal finish may be obtained by facing walls internally with *white tiles*, either to their entire height or to a portion thereof. *White glazed bricks* may also be used for this purpose with safety. The *floor* should be of hard, impervious material, a shallow drainage gutter being provided on two sides of the room, discharging over an external trapped gully connected to the drain. *Concrete*, or better still, *red flooring tiles* set in cement on a concrete foundation and laid with a suitable fall, should be used for this purpose. All *angles* should be rounded to prevent the accumulation of dirt. The *drainage* externally should be satisfactory, and should be connected with the liquid-manure tank if no sewer is available.

The provision of ample *natural* and *artificial light* is essential. Natural lighting may be provided either by means of windows or roof lights. The windows may be of the hopper type, opening inwards and similar to those provided in the cowshed ; or ordinary windows, at least half of which should be capable of opening. To prevent the entrance of flies when the windows are open, *gauze screens* should be provided. These are a great boon, as, while they do not interfere with light and ventilation, they guard adequately against the fly danger. The importance of satisfactory lighting cannot be over-estimated, as a great deal of the efficacy of the processes carried on in the milk room depends upon its adequacy.

The *ceiling* should preferably be flat, unless it is necessary to depend upon roof light as a means of natural lighting, in which case the roof should be cased in with *match-boarding* or *ceiling board*. This lining should be painted.

An ample pure *water supply* is necessary for cooling the milk and washing the floor and walls.

Provision must also be made for the *storage* of the utensils after sterilisation until they are required for use. It is not advisable that these should be stored in the washing room, as they are then liable to contamination. Galvanised gas-piping, suitably placed, makes a satisfactory rack which will not collect dust and is easily cleansed. The *bottling machine*, if one is provided, should be installed in the milk room.

Those portions of the walls requiring cleansing should be regularly limewashed. The internal surface of the walls not limewashed should be washed down after each milking to remove milk splashes, which form an attraction for flies. The floor should always be kept damp during operations in the milk room. As it is here that the cooling of milk takes place—the time during which the product is most liable to contamination owing to its longest exposure to air—the greatest care should be taken to ensure that the room is used for no purpose other than that for which it was provided. It is also desirable that all operations in this room should be carried out by one person, and that no cowshed worker should be allowed to enter the room on any pretext whatever. Cheese-and butter-making should not be carried out in the milk room, separate provision being necessary for these purposes.

The Sterilising and Washing Room

The size of the washing room depends upon the amount of the plant installed, but here again ample floor space should be provided. The farmer may rely only upon the ordinary type of washing copper for boiling water, or he may sterilise utensils by means of certain adaptations to be mentioned later. On the other hand, the output may be such that one of the many steam sterilising plants now on the market may be an economy. In either instance, the same principles apply.

The *walls* of this room should be treated similarly to those of the weighing room, while adequate natural and artificial light, an impervious *floor* with good drainage, and an adequate supply of clean water are also essential. The necessary hot water may be obtained from a copper or, if a steam boiler is installed, by blowing steam into a tank of cold water until the required temperature has been attained. If a *copper* is used, it is advisable that its furnace be fed from outside the room, because of dust arising from the fuel. Although the *steam boiler* may be fixed inside the room, it is advisable to place this outside for similar reasons.

Separate *tanks* for hot and cold water should be installed, adjoining which hardwood or metal draining racks should be provided. The tanks are best constructed of galvanised iron and fitted with drainage plugs so that they may be easily emptied after use. Large galvanised baths will be found satisfactory for the small farmer.

On many farms large *wooden tubs* are used for washing purposes. These should not be tolerated on any account, as, owing to the number of crevices which they contain and their rough surfaces, proper cleansing becomes virtually impossible, opportunity being thereby afforded for countless bacteria to contaminate the utensils. The *steam chest* should be placed as near the boiler as possible to economise in piping.

Boiler Room

Although it is not essential to provide a room to house the boiler and fuel, it is advisable that this should be done. As the situation of the boiler-house has little bearing upon clean milk production, always provided that it is fixed outside the washing room, the choice of the situation becomes a matter of cost and expedience only.

STERILISATION AND CARE OF UTENSILS

The importance of the proper sterilisation of utensils cannot be over-emphasised. Moreover, it cannot be too often stated that the use of the word " proper " implies sterilisation *with steam* and not merely a casual rinsing in hot or even tepid water, as so often appears to be the practice. There is no doubt that milk may be seriously contaminated in the cowshed by unsatisfactory milking methods, but such contamination, regrettable though it may be, is nothing to that which can be caused by the use of improperly cleansed and sterilised utensils. If milking is carried out under proper conditions, it is probable that only a small number of undesirable bacteria are added to the milk. The results of unsatisfactory sterilisation, on the other hand, are infinitely more serious, as dirty utensils themselves form excellent breeding-places for bacteria.

From the above it will be seen that the cleanliness of the utensils plays a vital part in clean milk production and distribution. *Dirty utensils spell failure.* It is a waste of time for the farmer to produce clean milk and then to store or distribute his product in improperly sterilised receptacles. The loss of milk throughout the country in a year through souring is very great, and it is a reasonable supposition that much of this souring could be avoided if sufficient care were exercised to ensure that all vessels used to contain milk were properly and efficiently sterilised before use and were properly protected after sterilisation.

The advent of the National Milk Testing and Advisory Scheme has focussed attention on the cleansing of churns, the methods employed at creameries, large distributing depots and collecting stations being given serious attention. Careful bacteriological examinations of the churns are made in accordance with a technique recently laid down. The maximum count specified by the Advisory Panel dealing with this matter is that no churn should, if efficiently cleansed, have a bacterial count of more than 50,000 organisms per millilitre. Methods of testing are described on page 371.

There has been a widespread belief that the producer is not legally obliged to wash and sterilise dirty churns received for the transportation of milk. This erroneous impression gained so much ground that in 1943 the Ministry of Agriculture issued a memorandum to the Press which fully explained the position. There it was definitely laid down that the responsibility of cleansing churns while primarily resting upon the purchaser of the milk, is legally shared between the purchaser and the seller.

As an instance of what efficient sterilisation can effect the following experiment may be quoted. Milk of low bacterial count was put into three similar types of churn. The length of time the milk kept sweet was as follows :—

Churn No. 1.	Washed only	1¼–1½ days.
Churn No. 2.	Washed and scalded	1½–2 days.
Churn No. 3.	Washed and sterilised with steam .	2½–3½ days.

The following results show the difference in the bacterial counts of bottled milk taken from a farm immediately before and after an efficient steam sterilising plant had been installed. The farmer, in this instance, although exercising great care in his production methods, had never been able to lower the bacterial content of his milk to the level warranted by his efforts.

Total Bacterial Count per ml.	Bacillus coli present in :
140,000	0·0001 ml.

Sample taken one week *before* the installation of the sterilisation plant.

8,700	Negative

Sample taken during the week *following* the installation of the sterilising plant.

A further example of the extent to which milk may be contaminated by dirty churns is given by Mattick.

TABLE 1

Condition of Churns on Inspection.	No. of Bacteria per ml. of Washings.	B. coli. found in :
		ml.
A. Apparently clean and dry	6,200,000	$\frac{1}{1000}$
B. Apparently clean, but wet	4,100,000	$\frac{1}{100}$
C. Milky water present	18,400,000	$\frac{1}{1000}$
D. Milk present	30,000,000	$\frac{1}{100,000}$

Each churn was rinsed with 1,000 ml. of sterile water, a portion of which was used for estimating the number of bacteria present.

If milk had been forwarded from the farm in any one of these churns, there can be no doubt that it would have been sour on reaching the distributor.

The essentials for the satisfactory hand-washing of churns are :—

(*a*) Thorough rinsing with 2 quarts of cold water to remove any milk.

(*b*) Scrub with hot water containing a suitable detergent (4 ozs. soda ash to 10 gallons of water).

(*c*) Rinse with clean water.

(*d*) Scrub the lids in hot detergent solution. The external surfaces of the churns should also be washed.

It will be observed from the above Table that it is not possible to judge the cleanliness of any utensil by its appearance. The fallacy of this attitude is well illustrated by this Table and also by Table 2 from the same source, which further demonstrates the impossibility of efficiently sterilising utensils without the use of steam.

TABLE 2

Apparatus.	Count per ml. of Washings.	Presence of B. coli in :	Remarks.
		ml.	
Cooler	80,000	$\frac{1}{10,000}$	Appeared clean—washed in hot and cold water.
Cooler	11,000	$\frac{1}{100}$	Appeared clean—washed in hot and cold water and steam sprayed on surface.
Cooler	1,464,000	$\frac{1}{1000}$	Greasy—washed in hot and cold water.
Receiver	3,870,000	$\frac{1}{100}$	Washed in cold water only.
Receiver	53,200	$\frac{1}{100}$	Washed in cold and hot water.
Strainer (Metal)	96,000	$\frac{1}{10,000}$	Appeared clean.
Milking Pail	3,000,000	$\frac{1}{10,000}$	Washed in cold water.

Each piece of apparatus was washed with 500 ml. of sterile water, a portion of which was used in making the counts.

It must also be stressed that the provision of a steam sterilising plant is not in itself an indication that the utensils will be efficiently sterilised. The proper application of steam is necessary for a sufficient period of time and at adequate temperature before one can guarantee that an article has been adequately treated.

PROCESS OF CLEANSING UTENSILS

Preliminary Treatment

Utensils should never be sterilised without preliminary washing and cleansing, and this process must be carried out in a proper manner. Milk contains fat which adheres to the surfaces of the utensils with which it comes into contact, and if milk is allowed to dry on these surfaces, its removal becomes a matter of considerable difficulty. All the utensils with which the milk has been in contact should first be washed and scrubbed in cold water. This removes the residue of milk adhering to the utensils and also the dust and dirt which may have collected on the outer surfaces. As it is not always possible to proceed with the washing of the utensils immediately after use, it is advisable to soak them thoroughly in cold water until the washing proper can begin. Care should be taken to ensure that hot water is never used for this preliminary operation. If this is done, the albumin in the milk will coagulate on the surfaces of the utensils, which coagulation renders efficient cleansing more difficult.

In the case of *very dirty articles*, the utensils are certain to require a very thorough preliminary scouring, and this should preferably be carried out with the aid of sand and cold water. Probably two or three applications will be necessary before the utensils are in a sufficiently clean condition. Having completed this initial cleansing, the ordinary treatment outlined below will be sufficient.

After washing with cold water, all utensils should be immersed in a tank of really hot water, and during this immersion they should be thoroughly scrubbed with a stiff brush to remove all fat which may still be adherent to the surfaces. The greatest care should be taken to ensure that the brush penetrates all corners of the receptacles. The addition of a small quantity of washing soda to the water materially assists the work of cleansing. If this is done, the utensils must be washed again in clean hot water, but this second washing is a good practice whether or not powder is used. Care should be taken to wash the *outsides* of the utensils properly, as well as the internal surfaces. If the outsides are left in a dirty condition, the hands of the workers handling those parts may become contaminated.

When the articles have been thoroughly washed, they should be allowed to drain for a short period, when they will be ready for sterilisation. It must here be emphasised that on no account should the articles be rinsed in cold water after the final rinsing in hot water. This is the present practice of many producers but, owing to the contamination which may take place, it cannot be too strongly discouraged. The water used for the final rinsing may be a source of bacterial contamination, and even if a pure water supply is available for this purpose, the fact that it leaves the utensils in a wet condition renders the practice inadvisable.

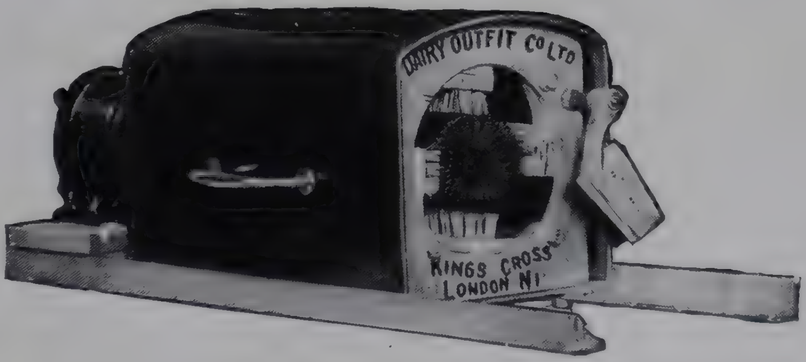


FIG. 58. "Vari-Brush" Electric Bottle Washer.

Two *galvanised-iron tanks* should be provided for the preliminary treatment, one supplied with hot water and one with cold. These are usually semicircular in section, 6–8 feet in length, and 2½ feet deep at the deepest part, i.e. along the centre. By means of a submerged steam jet the water can be raised to the desired temperature. For the proper cleansing of

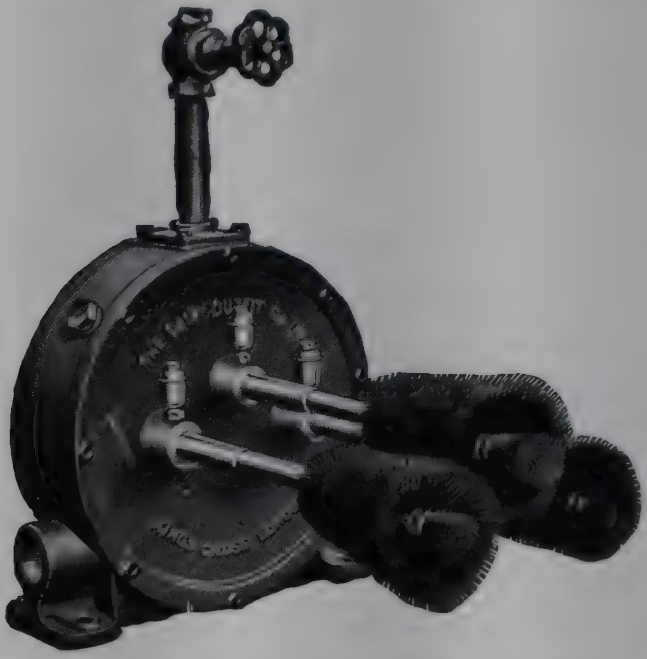


FIG. 59. Steam Turbine Bottle Washer.

bottles, if these are in use, a mechanically operated *brush*, similar to either of those illustrated, should be provided on each tank. These brushes, revolving at high speed, quickly and thoroughly cleanse the internal, and in some cases the external, surfaces of the bottles. The washing and sterilisation of bottles will be further dealt with in a later chapter dealing with the bottling of milk (see page 218).

Sterilisation

Technically an article is said to be sterile when it harbours no living bacteria, but in the dairy industry the word "sterilisation" possesses an added meaning in that it also implies the removal of all risk of contamination of the milk by pathogenic organisms. After the preliminaries of washing first in cold and then in hot water, the utensils have to be rendered free from bacteria by sterilisation. This can only be brought about by the use of steam or chlorine solutions, and although it must be definitely and emphatically stated that there is no substitute for steam which will efficiently sterilise utensils, it should once again be pointed out that such sterilisation should only follow a thorough cleansing of the articles.

The action of any sterilising agent depends for its effectiveness upon the time of exposure, the concentration of the sterilising agent and environmental conditions. Milk proteins complicate the problem because they have a tendency to protect bacteria from the action of sterilising agents. While detergents and chlorine solutions are employed for sterilisation purposes, heat, when properly applied, will be found most useful. If dry heat is used, however, much higher temperatures and longer exposure to the heating agent are required.

Many farmers scald their utensils by means of boiling water. The term "scalding" may include anything from washing out with warm water to the use of really boiling water, but in all such cases the temperature of the water varies and drops according to the distance which it has to be carried. There is also a further considerable drop following the scalding of the article.

It is this temperature drop which is the cause of inefficiency, since it cannot be overcome. Although this method has many advocates, there can be no comparison between scalding and sterilisation. Table 3 given by Mattick clearly shows the results obtained by the different methods.

TABLE 3

KEEPING QUALITIES OF MILK IN CHURNS TREATED IN DIFFERENT WAYS

Number of Days Sweet at 60° Fahrenheit

Sample No.	Control.[1]	Washed.	Scalded.	Steamed.
1	4	1½	2	4
2	3½	1½	2	3½
3	3½	1½	2	3½

[1] The control milk remained in the sterile vessel into which it was milked.

It will be seen from this table that there was not a great deal of difference between washing and scalding, and that neither method was to be compared with steam as a method of sterilisation.

Sterilisation, which is essentially a matter of time and temperature, must be effective, and to procure this effectiveness certain conditions have to be observed. These conditions are :

(1) The steam should be quickly available, and should issue from the outlet pipe within a limited time.

(2) The steam pressure must be retained throughout the steaming.

(3) It is impossible to sterilise efficiently unless the utensils are effectively covered.

(4) The sterilisation should be carried out in a place free from draughts.

(5) Some means of checking the temperature must be provided. The thermometers must be accurate and should be fixed at a point remote from the steam inlet.

The length of time during which the steaming process has to be maintained depends upon the apparatus used, but the temperature must be maintained as near 212° F. as possible. Later in this chapter, when the different means of sterilisation are detailed, the question of time will be more fully discussed.

Following efficient sterilisation there should be no condensed water in any of the articles, but if by any chance there should be some present, no attempt must be made to wipe it off, as this will undo the work already completed. The heat of the articles themselves should be sufficient to dry off any small amount of condensed water. Churns which are sterilised by inverting over a steam jet should be laid on their sides for a few seconds after steaming to allow the surplus steam to escape. The lids, which have been previously sterilised, must then be fixed. The churns need not be aired provided sterilisation has been effective, but should be immediately closed to maintain sterility until required for use.

Sterilisation must be carried out regularly and immediately after milking if it is to be effective. The effect of intermittent sterilisation has been demonstrated by Mattick, who gives the following table, showing the difference in the bacterial counts of morning and evening milk on different days when the morning milk was collected in utensils which had not been steamed.

TABLE 4

Sample No.	Age in Hours.	Temperature Tested.	No. of Organisms per 1 ml.
1 E . .	19	48° F.	21,000
2 M . .	4	48° F.	200,000
3 E . .	20	47° F.	31,000
4 M . .	5	49° F	88,000
5 E . .	19	46° F.	15,000
6 E . .	5	56° F.	19,000
7 E . .	19	56° F.	46,000
8 M . .	4	64° F.	72,000

E = Evening Milk. M = Morning Milk.

The articles used in the cleansing of the animals should be washed and sterilised daily. This also applies to the milking stools.

It is advisable to pass all the articles after sterilisation through the hatch provided between the milk room and the washing room without delay, after which they should be stored on racks provided for the purpose until needed. They may, however, if so desired be kept in the sterilising tank until required for use.

The Provision of Steam

The cost of an up-to-date steam sterilisation plant, which comprises boiler, tanks, and steam chest, together with the necessary piping, may place the apparatus out of reach of many milk producers, but this difficulty should not be allowed to prevent the sterilisation of all utensils by steam. By simple means, an ordinary domestic copper can be effectively used for sterilisation work. There are several ways of converting the copper for this purpose.

For the sterilisation of churns, pails, etc., an aperture should be bored in the lid, sufficiently wide to take a 3-inch length of 2½-inch diameter pipe. Such an arrangement is shown in Fig. 60 (A and B). Four ½-inch battens or strips of metal are fixed at right angles on the lid as shown in Fig. 60, A to allow for the drainage of the condensed water and to prevent the lip of the churn, etc. coming into contact with the lid, thus avoiding further contamination.

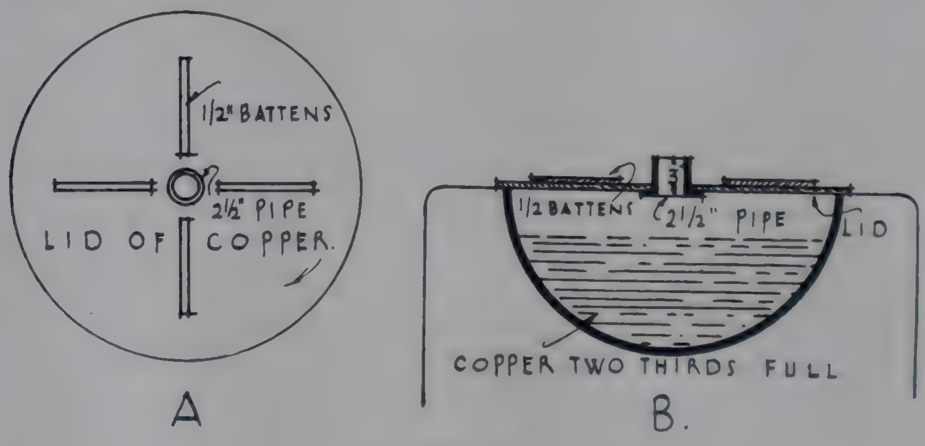


FIG. 60

The small utensils and bottles require different treatment, and for their steaming one of the devices shown in Figs. 61 and 62 may be provided.

Fig. 61 demonstrates the manner in which a special galvanised-iron box with removable shelves can be placed over the pipe fixed in the copper lid. One side of the box is hinged to form a door, and drainage holes are provided for condensed water. The tank is not very costly to provide.

Fig. 62 illustrates a further example of economy with efficiency. An ordinary galvanised-iron household dustbin, such as can be purchased at any hardware store, is placed over the copper after removal of the copper lid. The base of the bin is perforated with 1-inch apertures, through which the steam enters the bin. A tight-fitting lid is provided, this being removed to fill the bin with the utensils to be sterilised.

Before any sterilisation can take place, the water in the copper must be boiling vigorously. A thermometer held in the steam will quickly show when the requisite temperature (212° F.) has been reached. The churns and pail should be taken first and inverted over the pipe fixed in the lid of the copper, as shown in Fig. 60. Each article should be allowed to remain in this position for ten minutes, the water boiling vigorously throughout. While this is in progress the box or bin should be filled with the smaller articles, such as the cooler, strainers, brushes, and straining cloths. When the sterilisation of the churns and pails has been completed, the box or bin should be hoisted into the position shown in Figs. 61 and 62. Care must be taken to ensure that the water continues to boil. After sterilisation, for which a further period of ten minutes is required, the receptacle should be removed with the water still boiling, so that condensed water does not accumulate on cooling.

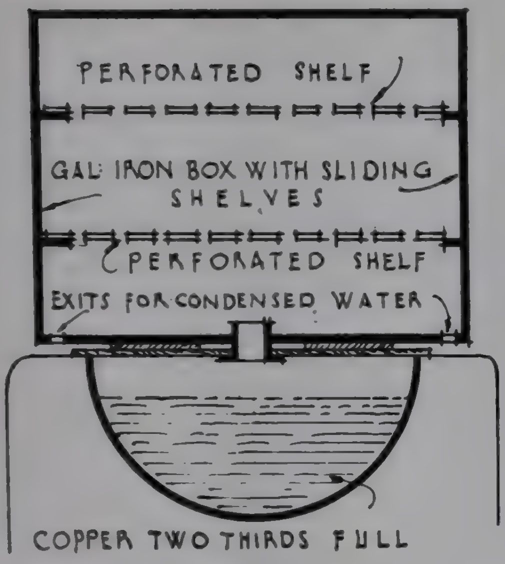


FIG. 61.

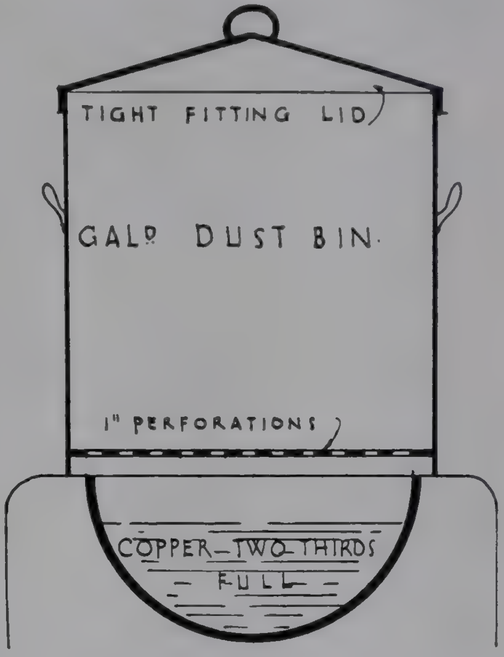


FIG. 62.

The receptacle used should be approximately 3 feet square by 2 feet 6 inches deep. The utensils may be removed to the milking room immediately after cooling without fear of contamination. They may also be left in the tank, but, if this is required for the sterilisation of a further batch of utensils or bottles, it will not be possible to treat them in this manner. It is also probable that much of the early rusting experienced with all metal utensils is due to this practice.

The copper should be emptied daily to prevent the risk of contamination during the sterilising process. The water in the copper may be heated either by coal, in which case the firing door should preferably be placed outside the washing room, or by gas, which is a very satisfactory and clean source of heat.

An improvement on the above method may be obtained by means of what is known as the *Simple Steam Steriliser.* Fig. 63 shows a section through this type of apparatus.

The apparatus consists of a shallow tray 2 feet by 1 foot 4 inches, holding approximately 1 gallon of water. An insulated cover is provided, with a steam pipe for use when sterilising pails and churns. It is supported on an iron stand, and heat is applied by two Primus stoves burning paraffin. This apparatus may be used with a steaming box as illustrated in Fig. 64.

The steaming box, which is insulated, is arranged to stand over the tray, the insulated cover having previously been removed. The box is provided with a perforated base, and a thermometer is also necessary.

One of the greatest advantages possessed by this apparatus is the fact that steam is raised very quickly, in approximately ten minutes after lighting the stoves. The stoves require careful attention, and only paraffin oil of the highest quality should be used. Cheap oil tends to clog the jets with dirt, with a consequent loss of constant heat. Gas may also be used for heating purposes. Owing to its simplicity and its cheapness, this apparatus should recommend itself to many farmers who cannot afford expensive plant, but who would prefer something rather better than the conversion of a domestic type copper.

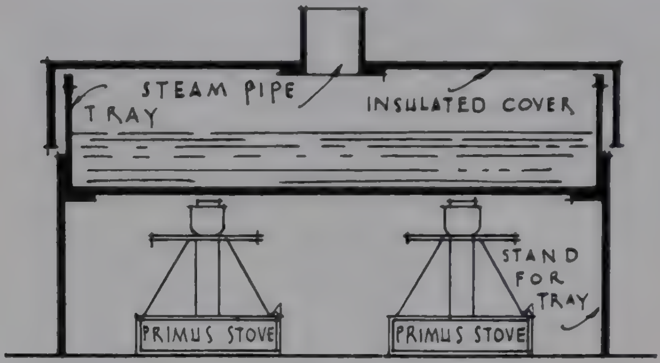


Fig. 63.

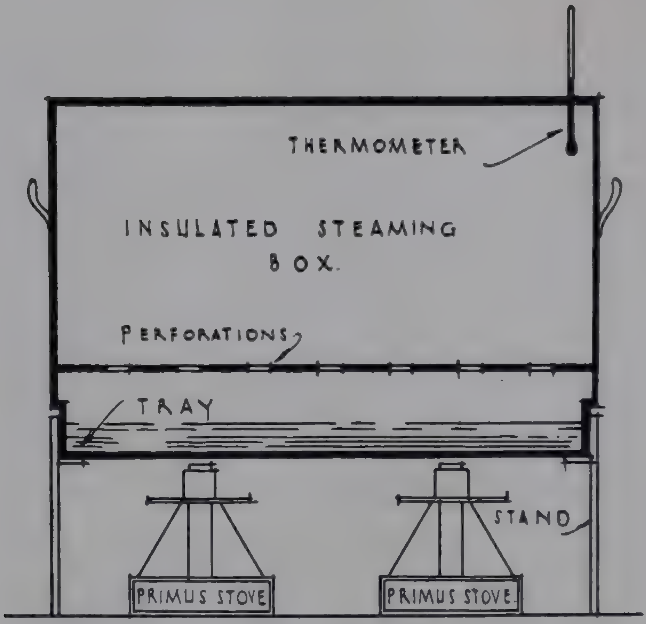


Fig. 64.

These methods, whilst entirely satisfactory if properly carried out, can never take the place of suitable *steam-sterilising plant* with the necessary boiler, steam chest, hot- and cold-water tanks, power-driven brush for bottles, and steam stand-pipe for the churns which should always be provided whether the quantity of milk to be handled is large or small.

The commonest type of *steaming block* for churns consists of a wooden block with a steam jet in the centre, to which steam or cold water may be fed as required. The wooden centres of such blocks rapidly deteriorate and an improved type of steaming block is shown in Fig. 65. This is entirely constructed of metal, and is provided with multiple jets in place of the older type of central jet. With this apparatus, hot or cold water or steam can be applied at will from four different points in a diagnonal direction, each point consisting of four distinct jets. This creates a powerful swirling motion.

which thoroughly cleanses and sterilises every portion of the internal surface.

There are several types of *steam boilers* on the market, but whatever the type or make, the boiler must conform to certain important requirements, as follows:

(1) Must give a continuous flow of steam as and when required.

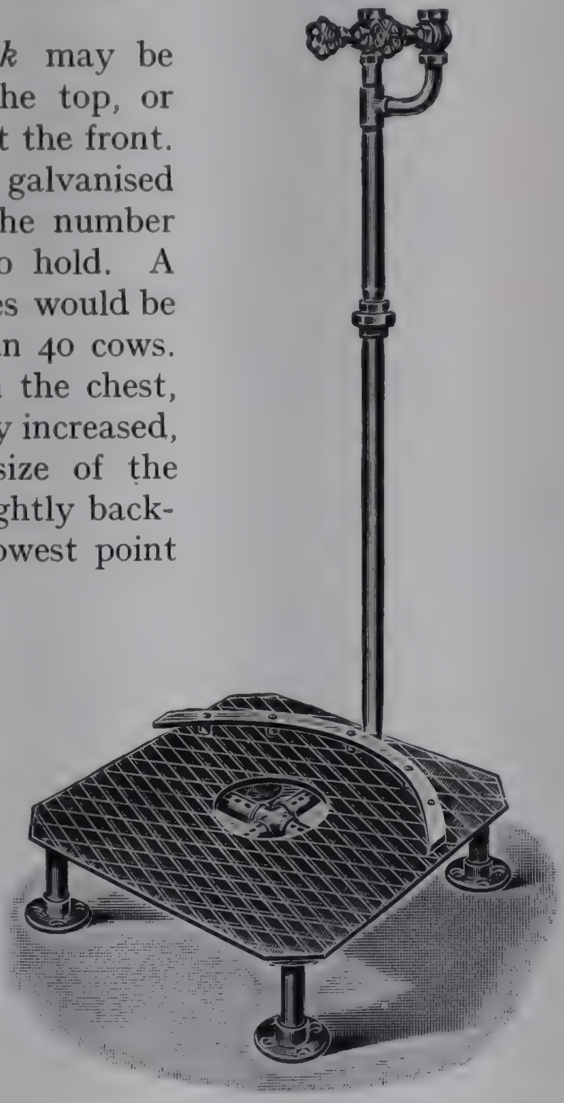
(2) Must raise steam quickly and maintain a steam pressure of 15 lbs. per square inch with adequate evaporation (i.e. 60 lbs.) which is the essential factor.

(3) Should be economical in the use of fuel.

(4) Should be of requisite size, not too large to be uneconomical or too small to be inefficient.

The boiler should be housed in a separate room adjoining the washing room. Care must be taken to ensure that a sufficient water supply is provided.

The *steam chest* or *sterilising tank* may be constructed either with the door at the top, or what is more common, with the door at the front. They are generally manufactured of galvanised iron, and vary in size according to the number of articles which they are required to hold. A tank 3 feet by 3 feet by 4 feet 6 inches would be satisfactory for a herd of not more than 40 cows. If it is intended to steam the churns in the chest, the size would require to be considerably increased, with a comparable increase in the size of the boiler. The tank should be tilted slightly backwards, with a small aperture at the lowest point to allow the condensed water to drain away. A metal grid should be placed some 3 inches above the base of the tank to prevent articles touching the bottom and also to allow for drainage and free circulation of steam. A thermometer should always be provided, as correct temperature readings are essential, but it is important that such thermometers should be accurate. In many cases, sterilisation has been unsatisfactory on account of inaccuracy. The instrument should be fixed at some point remote from the stream inlet. The lid should, when closed, be perfectly steam-tight, and is best secured by means of bolts and butterfly nuts or screw clamps. The inlets from the boiler should make provision for the incoming steam to be distributed evenly over the entire interior.

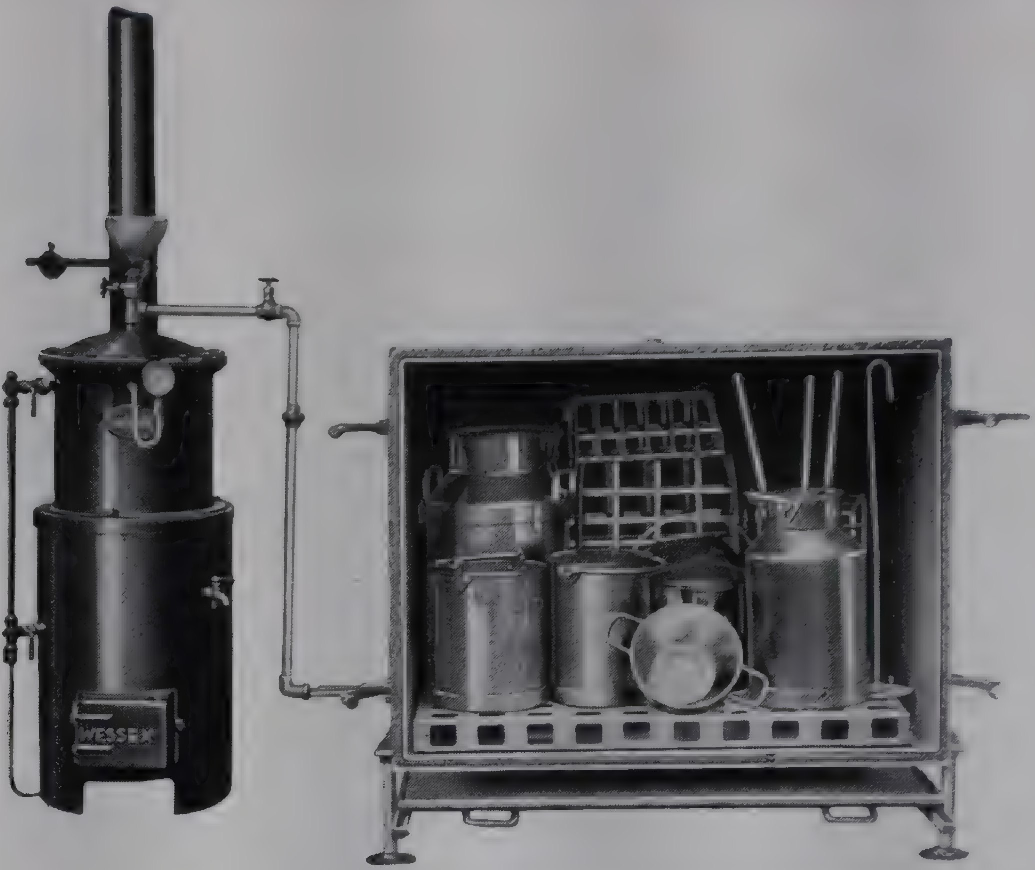


By courtesy of the Dairy Outfit Co., Ltd.

FIG. 65. All-metal Steaming Block for Churns.

Certain factors affect the efficiency of steam sterilisers. In some instances it will be found that the steam chest may be too large for the capacity of the boiler which feeds it. A most important item is the expense of operation which is a constant charge on the cost of milk production. The length of time required for the chest to reach sterilising temperature and the attention which must be paid to its operation are also points which require to be considered.

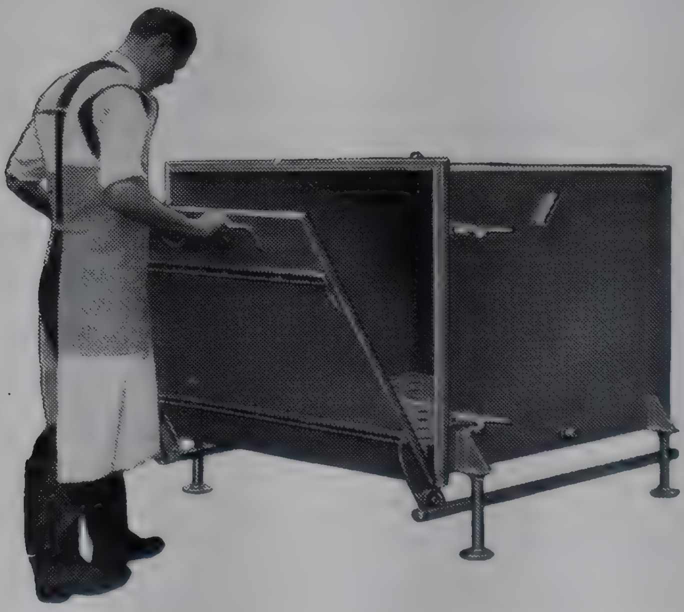
There are many types of plant to be obtained, making use either of low or high-pressure steam, and a few of these deserve brief mention.



By courtesy of Clare's Service.

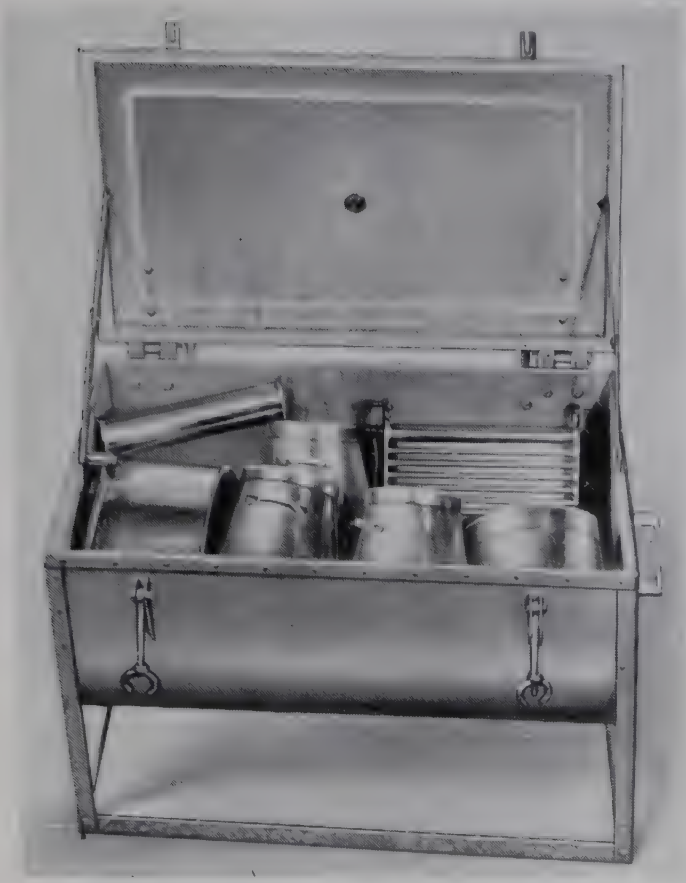
FIG. 66. "Wessex" Sterilising Outfit.

(1) *The "Wessex" Steriliser.* This apparatus works at a pressure of 15 lbs. per sq. inch and is to be recommended for the producer or small retailer. It consists of a boiler and extra large sterilising chest which is provided with a perforated steam pipe passing across it and is fitted with a galvanised lattice steel rack and thermometer. This apparatus is illustrated in Fig. 66, while Fig. 67 shows another view of the steam chest.



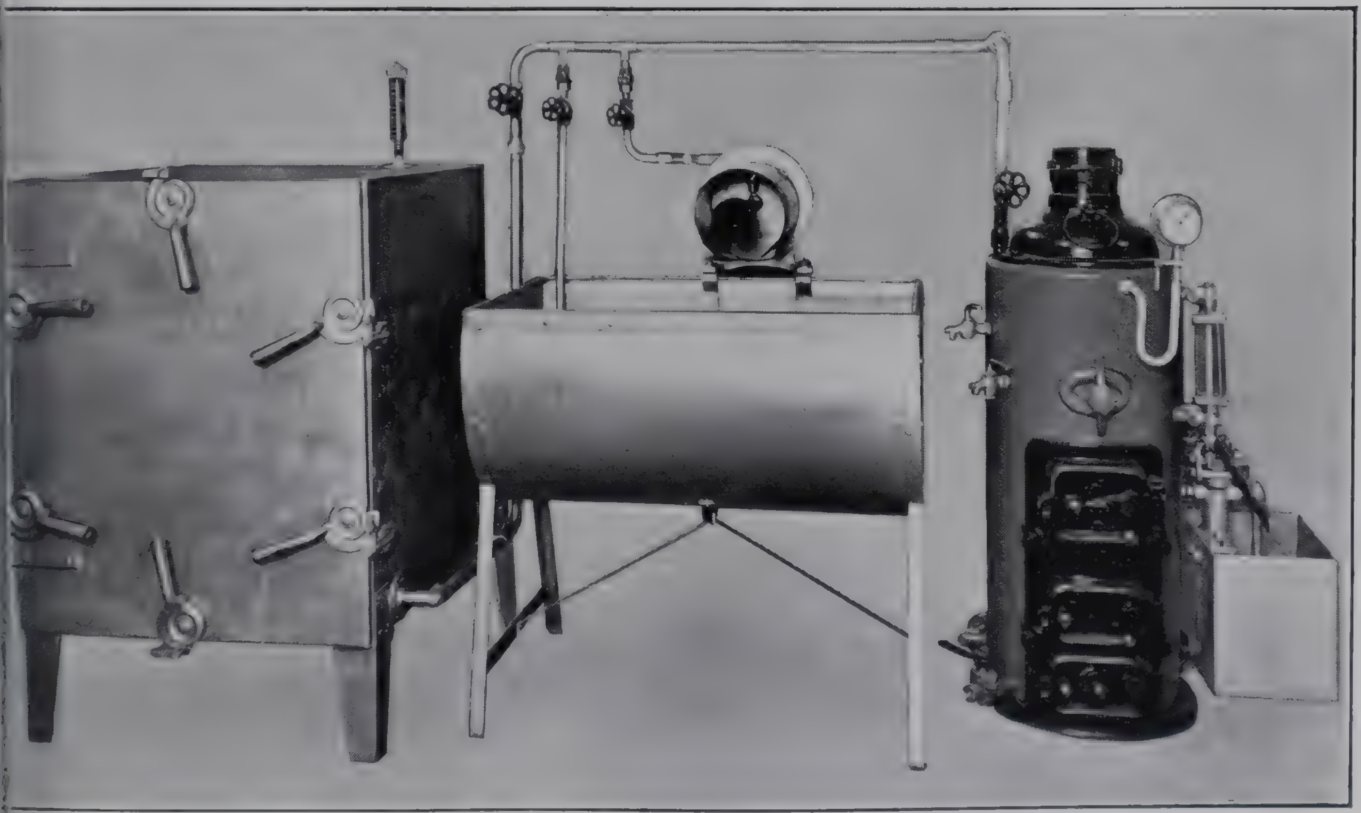
By courtesy of Clare's Service.

FIG. 67. "Wessex" Super Sterilising Chest.



By courtesy of Clare's Service.

FIG. 68. "Wessex" Steri-Trough.

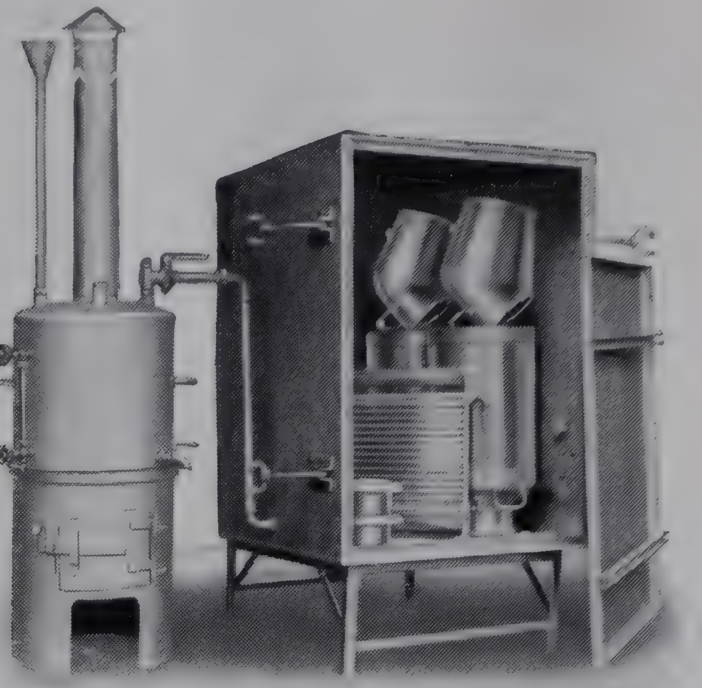


By courtesy of the Dairy Outfit Co., Ltd.

FIG. 69. "D.O.C." Sterilising Plant.

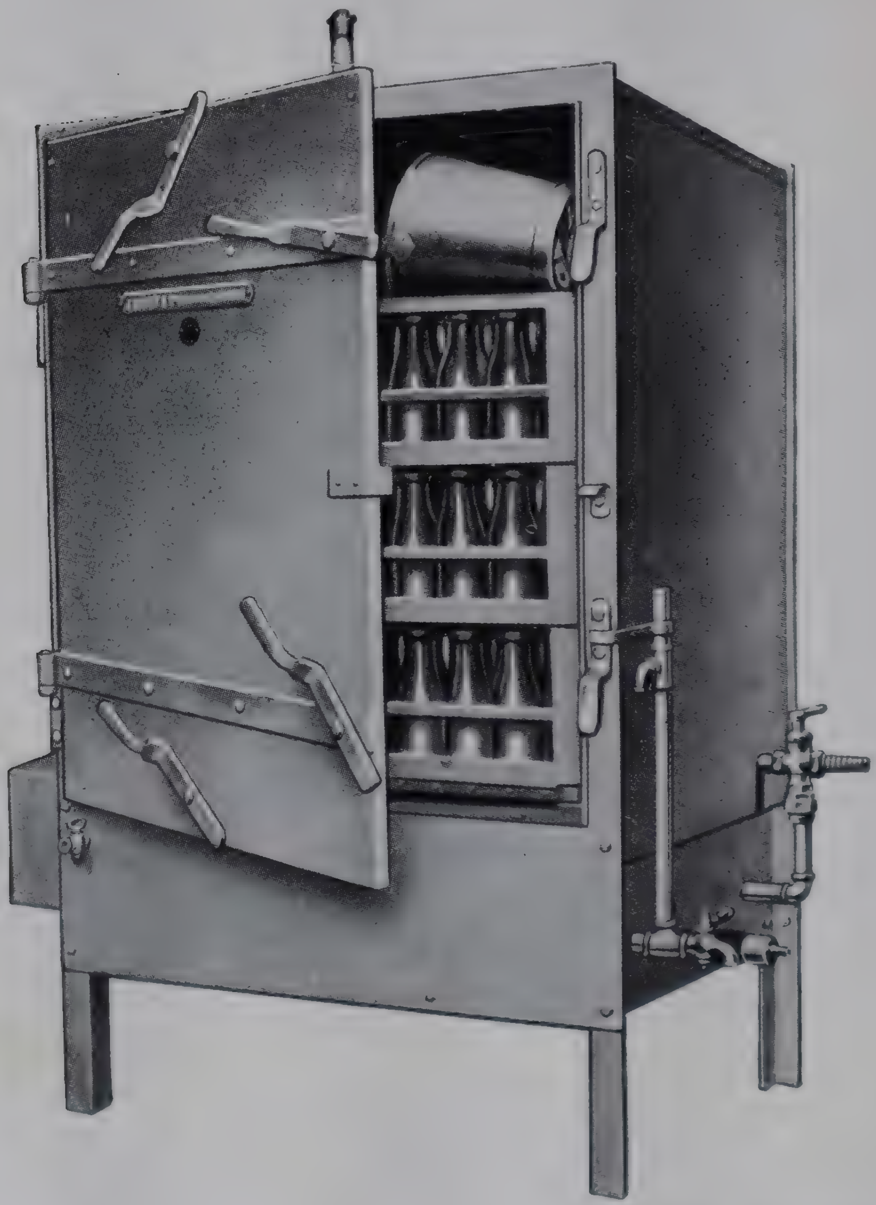
(2) The *"Wessex" Steri-Trough.* This is a novel idea combining washing trough and steam chest in one piece of apparatus. Its dimensions allow for the sterilisation needs of a 20 to 30-cow dairy. A thermometer is provided and the apparatus is solidly constructed.

(3) *The "D.O.C." Sterilising Plant.* This plant, manufactured by the Dairy



By courtesy o Perfect Dairy Machines, Ltd.

FIG. 70. "Desco" Low-pressure Steam Steriliser.



By courtesy of J. Stott and Co.

FIG. 71. "Stott" Gas-heated Steriliser.

Outfit Company, consists of a high-pressure tubular boiler and washing-trough for soaking and rinsing, and is supplied with a steam-turbine bottle brush and sterilising chest fitted with a steam trap. The washing-trough is divided into two parts for hot and cold water by a double partition which is heated by steam, obviating any heat loss from the hot-water section. The boiler may be fitted either adjoining the tank or some distance away as desired.

(4) *The "Desco" Low-pressure Steriliser.* This type of plant is cheap but its low cost does not result in any loss of efficiency, and with such plants obtainable, no producer or distributor can plead that high cost prevents the installation of a proper and efficient steam-sterilising system. The plant, which is manufactured by the Perfect Dairy Machines Ltd., consists of a steam chest and boiler, but tanks can be added if desired, although such are not advisable owing to the low steam pressure at which the plant operates. A thermometer is provided with the steam chest, which may be of the horizontal or upright type as desired.

(5) *The "Wembley" Steriliser.* This apparatus is manufactured by Messrs. Aveling-Barford Ltd., and consists of a boiler, steam chest, and washing-trough. The trough is divided into two parts for hot and cold water, and a steam-turbine brush and a bottle rinser are also fitted. The door of the steam chest can be of the hinged or lift-off type as desired, and the chest is fitted with a thermometer.

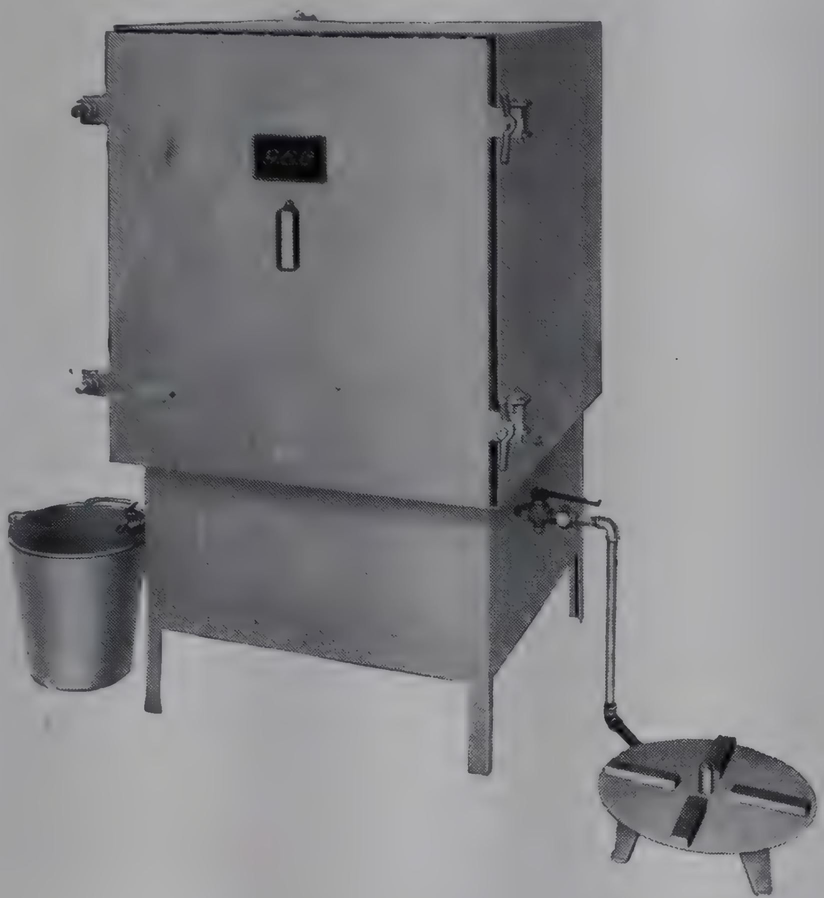

By courtesy of Clare's Service.

FIG. 72. "G.E.C." Electric Steriliser with Churn Block.

(6) *The "Stott" Gas-heated Steriliser.* This steriliser, which is constructed in two sizes to deal with either 120, 240 or 360 bottles at one processing, does not require a separate steam generator, as it is an entirely self-contained and compact unit. The steam generated is super-heated to a high temperature within a reasonable time, due to the heat-conserving jacket with which the apparatus is fitted. A special device ensures the drying-off of all bottles and utensils before they leave the cabinet. A churn steaming block may be attached if desired.

An automatic water supply is provided, and a reasonable amount of hot water, up to 10 gallons, may be drawn off for washing purposes. In addition to a suitable thermometer, the apparatus is provided with thermostatic control.

(7) *The "Stott" Electrically-heated Steriliser.* This apparatus is eminently suitable for those who possess available electric power, and who wish to obtain an economical, self-contained unit. The steriliser is fitted with an automatic water

supply, thermostatic control and thermometer, and will handle either 144 or 288 bottles at each treatment, according to size. The sterilising temperature is attained within twenty-five minutes of commencing operations, after which a large proportion of the heat is not required, the balance being sufficient to maintain the necessary temperature.

There is also an *electric steriliser* on the market which is a product of the General Electric Company. The full sterilising operation may be carried out in one hour with a consumption of eight units of electricity. The method of sterilisation is simple. The current is switched on when the chest has been filled with utensils. At the end of one hour it is switched off, sterilisation having been completed. Very little water is used, the steam generated is particularly " dry," and the utensils dry off quickly and efficiently. A thermometer is provided and a steaming block may be connected, as shown in Fig. 72, if desired.

Following the process of sterilisation, the lid of the steam chest should be opened slightly after the steam has been turned off, to allow the steam to escape. It should then be closed for ten minutes to allow the heat to dry off the contents. This will be found very useful in preventing the utensils, especially any bottles which may be steamed, being affected with condensation on their internal surfaces.

Sterilisation with Chlorine Solutions

The Milk and Dairies Regulations, 1943, repealed Article 21 of the Milk Dairies Order, 1926, and this Article was redrafted to permit the sterilisation of milking utensils with solutions of sodium hypochlorite. The amendment does not abrogate the requirement that milk vessels should be sterilised with either boiling water or steam but merely permits the use of such solutions as are approved by the Minister of Agriculture and Fisheries for the cleansing of milk utensils and limits the varieties of oxidising and preservative agents which may be employed for this purpose. This step has supposedly been taken on account of the need for economy both in metal, of which sterilising plants are constructed, and in order to save fuel as a means of assisting the war effort.

The solutions recommended are :

(1) Deosan.
(2) Chloros.
(3) Dairozon
(4) Hyposan.

It is laid down that the product shall have a total available chlorine content at the time of its despatch from the manufacturer's premises of between 9 per cent. and 12 per cent. W/W plus or minus 0·5 per cent. and that it should contain not less than 0·7 per cent. of sodium chlorate to act as a detector.

It must be emphasised that chlorine solutions should only be used in the unavoidable absence of steam for which they are only a substitute. They have little or no penetrative power and in this respect cannot be compared with steam or boiling water. Unless the washing of the utensils with such solutions is thoroughly carried out organisms remaining in crevices or scratches in milk films or in rusty patches will not be destroyed by these solutions. With the granting of permission to use such substances, some dairymen immediately concluded that they need no longer use boiling water or steam and it cannot be too strongly emphasised that chlorine solutions should only be used in case of dire necessity.

The hypochlorite solutions set out above are relatively stable and the manufacturers' statements as to the percentage of available chlorine may be accepted. Under good storage conditions in a cool dark place these solutions should not lose more than 0·5 per cent. of available chlorine each month. Two solutions are necessary. These are:

(*a*) The *Chlorine Wash*. This is made in a clean churn in water warmed to 105° F. or higher and sufficient stock hypochlorite is added to give 250 to 300 p.p.m. (per million parts of water). The chlorine concentration should never fall below 150 p.p.m. during use and this wash is intended for washing, spraying or flushing. One-quarter per cent. soda ash should be added to act as a detergent.

(*b*) *Chlorinated Water*. This is prepared by adding stock hypochlorite solution to clean water to give 5 to 10 p.p.m. of chlorine and is used for rinsing the vessels after the chlorine wash has been applied.

A *chlorine rinse* may be given to milking machines immediately prior to use. This is prepared by adding sufficient stock hypochlorite to water to give 50 p.p.m. of chlorine. No washing compound should be added.

The methods by which such solutions are employed vary according to the article to be treated as follows:

(1) **Milking Machines** (**Bucket Type**)

The buckets are first washed on their external surfaces, after which two or three gallons of water are drawn through each unit. The teat cup clusters are well washed by immersion and the inside of each cup is well brushed. The teat cup and milk tube are then immersed in a bath of hot chlorine wash together with the lids from the buckets and are well brushed. All parts should be kept immersed as much as possible during these operations. After a thorough washing, the parts are then rinsed in chlorinated water and hung up to drain. The buckets are then well scrubbed in chlorine wash and finally rinsed in chlorinated water. Three gallons of chlorine wash are required for each unit in use and units should be dismantled and scrubbed in hot chlorine wash at least weekly. Brushing is not essential after the evening milking but careful immersion in the solution is essential.

(2) **Auto-Recorders**

The teat cups are first well washed and brushed, after which hot chlorine wash is drawn through the system, 6 gallons of solution being necessary for each set of clusters, after which they are well brushed. The cups and milk line are afterwards flushed with chlorinated water.

In the summer months, a chlorine rinse should be given just before milking commences and during all periods of the year vacuum pipe lines should be flushed at least once a week with chlorine-soda solution, after which they should be rinsed with clean water.

(3) **Small Utensils**

Pails and other small utensils are best sterilised by immersion and scrubbing after a preliminary cold water wash. They should be treated in a hot chlorine wash, being kept immersed as much as possible during the process. They are finally rinsed with chlorinated water and allowed to drain.

(4) **Milk Churns**

After preliminary washing and brushing with cold water, one gallon of hot chlorine wash is added to each churn and all internal surfaces together with the lid are thoroughly brushed. The churn is then rolled vigorously for one minute so that the solution reaches every part of the interior, given a final rinsing with chlorinated water and allowed to drain.

When large numbers of churns require to be dealt with, they should be well sprayed when the above process has been carried out, this treatment lasting for one minute, per churn. Any satisfactory spraying machine may be used.

(5) Storage Tanks, etc.

These are first washed in the normal manner and are then well sprayed with chlorine wash. The spraying time occupies from three to seven minutes according to the size of the container, each 10 square feet of interior surface being sprayed for fifteen seconds. After this treatment the internal surfaces should be hosed with mains water and the tanks left open to dry.

(6) Milk Bottles

Sterilisation is carried out by total immersion in chlorine wash for two minutes, after which they should be allowed to drain for some time before they are used. Crates should be treated in a similar manner.

It should be pointed out that *all milking machines and milk utensils should be sterilised with steam or boiling water for two minutes at least once weekly* in addition to the aforementioned treatment.

Permission to use such materials may prove of considerable assistance to the dairyman who has no proper sterilising plant or who experiences difficulty in obtaining same and should abolish the excuse of inability to sterilise equipment in an adequate manner. On account of ease of application the use of such solutions will allow the producer to sterilise his apparatus twice daily, a practice which is rarely carried out on innumerable farms. No doubt many interested persons will regret the decision to allow the use of such substances but, as permission has been granted, steps should be taken to ensure that the solutions are properly employed whilst pressing for the installation of steam sterilisation at every opportunity. It would be an advantage if milk depôts could undertake the regular issue of sodium hypochlorite solutions in small quantities to their producers, when the likelihood of excessive purchasing, waste or the excuse of inability to obtain would be removed. Small containers holding marked doses for given quantities of water would also be of considerable assistance.

Water Supply in the Dairy

It has already been indicated that the dairy must be provided with an adequate and pure supply of water, this applying to all dairies irrespective of size. The water supplies of this country vary in hardness, and this must be taken into account. The problems in the dairy industry arising from *hard water* are often considerable. Water in its natural state may contain salts of lime and magnesia, chiefly carbonates and sulphates but occasionally chlorides and nitrates, in varying proportions according to the source of water. These salts may be contained in water in four different ways:

(1) In suspension.
(2) In the form of an emulsion.
(3) As dissolved gases.
(4) As dissolved chemical salts.

Water in the dairy is used for a variety of purposes but chiefly for washing and boiler use, and it is important that it should be free from such impurities as are likely to cause film or rust. One of the difficulties of those forced to use hard water has been the presence of dissolved chemical salts, which can only be eliminated by a combined chemical and mechanical process which will soften the water and render it fit for industrial use.

Water may be softened by three methods :

(1) **The Lime-Soda Process.** The removal of temporary hardness is brought about by the addition of a sufficient quantity of lime. Twice as much lime is required for the removal of such hardness when it is caused by magnesium bicarbonate. Permanent hardness, due to calcium salts, is removed by the addition of soda-ash to form calcium carbonate, which is precipitated. Permanent hardness due to magnesium salts is removed by the addition of the required amount of lime and soda-ash.

(2) **Caustic Soda and Caustic Soda-Soda Ash Process.** When this method of water softening is used, caustic soda alone or a combination of soda-soda ash can be used to precipitate the calcium carbonate and magnesium bicarbonate, caustic soda being added for the removal of temporary hardness. Permanent hardness due to calcium salts is removed by sodium carbonate, as in the case of the lime-soda process.

(3) **The Base Exchange Process.** This is carried out by making use of the property possessed by certain mineral compounds, of exchanging part of their constituent elements for other chemical elements in liquids with which they are brought into contact. Cases have been known where the beds of base-exchange materials in such plants have heavily contaminated water passing through. This may be overcome by treating them with active chlorine during the brine regeneration process on successive occasions.

There are various types of water-softening plant available for those who contemplate the installation of such apparatus, but the advantages and disadvantages of these need not be discussed in a volume such as this. In choosing a water-softening plant it should always be remembered that the treatment of water for commercial purposes is definitely a scientific process, and users, before deciding upon any particular type of equipment, should have their water analysed by a qualified chemist and be guided in their choice of machine by a firm experienced in water-softening systems.

The water supply is of vital importance as not only must copious amounts at low temperature be available, but such water should be of equal quality to drinking water both from a bacteriological and chemical standpoint. This may be easy of attainment if the supply is taken from the mains, but is not always possible to achieve when obtained from a well sunk on the site, although if an artesian well is bored, no difficulty should arise. Water should be clear and colourless with as low a temperature as possible and should contain not more than mere traces of ammonia or any nitrites. Nitrates (N_2O_5H) should not be present in greater percentage than 0·003 while the water should possess the least possible amounts of chlorides with only traces of phosphates present.

CHAPTER VI

CLEAN MILK PRODUCTION

Introductory

PRIOR to the War of 1914–18 singularly little was heard of clean milk production, farming being carried on with quantity as the only desideratum, except in the case of a few enlightened producers. Farms were, of course, inspected by the local public health officials, and some efforts was made to enforce the provisions of the now defunct Dairies, Cowsheds, and Milkshops Orders. The further control of this country's milk supplies by attention to proper hygienic methods of production and distribution, bacteriological examination of milk, and an awakening of producer, retailer, and consumer to a sense of their individual responsibilities was unheard of except in a few isolated instances, chiefly in the large towns. In the years immediately preceding the last War, an agitation arose in the public press and elsewhere on the subject of clean milk, this agitation being at its height during 1914. Various medical, veterinary, and agricultural authorities wrote and lectured on the dangers of impure and dirty milk, and the public at last began to realise the fact that everything was not quite as it should be with the milk industry. The effect of this agitation was demonstrated in 1915, when the Milk and Dairies (Consolidation) Act was placed upon the Statute Book, although the consequent upheaval caused its operation to be temporarily suspended. The public has reason to be thankful that the stalwarts of that clean milk campaign survived those years, and that when peace came they once again reopened the issue and paved the way for further progress.

In 1922 the Milk and Dairies (Amendment) Act became law. This fixed a date for the operation of the principal Act of 1915, which finally came into force on September 7th, 1925, ten years after its having been passed. The Amending Act also gave local authorities several important and useful powers, and in it Graded Milks were mentioned for the first time, these grades being subsequently revised by the Milk (Special Designations) Order of 1923. Power was also given to local authorities under this Act to take samples of milk and to incur the necessary expense for their bacteriological examination. This, it should be noted, proved a very useful clause. In 1926, after the 1915 Act had come into operation, the present Milk and Dairies Order was issued, provision for this having been made in the principal Act.

Such is the brief history of the legislation by which the milk industry has been governed from a public health standpoint.[1] It required fifteen to twenty years to obtain suitable legislation, chiefly owing to the delay brought about by the first world War, and also, it should be added, owing to the efforts of the conservative element of the agricultural community which was in the main against any revolutionary change or interference with the existing methods of production. Happily for all concerned, the effect of the legislative measures, while not entirely satisfactory, has been to bring about not only an improvement in the standard of production, but also a fuller realisation of the value of scientific methods. Certain legislative amendments have occurred during the last few years, chiefly in the consolidation of existing Acts, but finality has not yet been reached even though the control of milk production will soon pass to the Ministry of Agriculture and Fisheries.

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[1] See Chapter XI for further particulars and amendments.

The control of the country's milk supplies forms a very complex problem, covering as it does so wide a field and so great a variety of interests. Milk from production to consumption is handled by or is under the care of numerous persons. The producer, the retailer and consumer are all intimately concerned, as are also the bacteriologist, the veterinary surgeon, the public health official, the county advisory staffs, and various other persons interested in the education of the agricultural community from the point of view of a clean milk supply. The legislation is designed to one end—the supply of pure, clean, wholesome milk to the public, and the efforts of all concerned or interested in the milk supplies of the country should be applied to this purpose. The animals must be healthy and clean ; the cowshed must be well-designed, and its surroundings sanitary ; the methods of the producer and distributor must be hygienic and up-to-date ; the officials concerned must direct their efforts towards educational work and control, while the consumers must also play their part in the scheme. In short, united action between all concerned is essential if any permanent measure of success is to be expected.

During the last few years the necessity for clean milk production has become an even more clamant problem, owing to the increasing quantity of milk produced and consumed and the loss of milk through souring. Lack of education had formerly a retarding influence upon its sales, while much damage has been done by sensational press accounts of the impurity of the country's supplies. The farming and dairying community have good reason to thank the National Milk Publicity Council and the Milk Marketing Board, by reason of their efforts in popularising the use of milk. The poor keeping quality of milk in the past has also affected its consumption in an adverse manner, this defect, due largely to carelessness on the part of the farmer, having prevented consumers gaining confidence in the supply, with a resultant rapid rise in the consumption of tinned milk.

The keeping quality is entirely dependent upon the cleanliness of the milk, which in turn depends upon the methods used in its production and distribution. This lack of keeping quality has not only retarded the growth of sales, but has also caused enormous losses due to premature souring, and this, without any doubt, is the primary reason for the inauguration of the National Milk Testing Scheme.

It is frequently stated by producers that clean milk is costly to produce owing to the large amount of extra labour involved and the expensive buildings and equipment necessary if success is to be achieved. This, however, is an entirely erroneous conception. A first-class product may be produced in moderate buildings with inexpensive equipment. Similarly, dirty milk may be produced in elaborate buildings with the finest of equipment in use. *To sum up, clean milk can be produced by any person having the will to succeed and the fixed determination to continue the necessary work every day, every week, and every year.*

Clean Milk

"*Clean milk*" does not mean milk in which all visible dirt is absent or milk from which such has been extracted. The term should rather be used to denote raw milk from healthy cows which has been produced and handled under hygienic conditions ; which contains only small numbers of harmless bacteria and which is capable of remaining sweet from delivery to delivery in summer and for four to five days in winter without being treated by heat.

The sources of milk pollution are so many and varied that, if care is not taken, its bacterial content soon becomes complex. If those responsible for its handling exercised strict methods of cleanliness on all the stages of its journey from the cow to the consumer, any serious addition to the number of bacteria already in the milk could be avoided. It is only too true to state that practically all the troubles experienced by the producer and distributor, not forgetting the consumer, are due to the activities of organisms which, by the exercise of care, can be largely excluded from the milk.

The character of milk changes from the moment it leaves the udder in proportion to the number of bacteria which obtain entrance to it. Some of these may be definitely pathogenic, some may be otherwise harmful or potentially harmful, while there are others which cannot be considered to have any detrimental effect *per se.* The conditions most likely to accelerate bacterial growth are moisture, suitable temperature, air, and nutriment, and milk, which supplies all the essentials to their existence, is without doubt one of the most favourable media for the growth of organisms.

Contamination of Milk

It has already been stated that milk is liable to contamination to a greater or lesser degree by bacteria, and it is therefore essential that the sources of pollution to which it is subject between production and consumption be sufficiently understood.

The primary sources of contamination occur at the point of production, the first focus existing in *the animal* itself. An unhealthy animal or one with a diseased udder can add countless pathogenic bacteria to the milk which it supplies. In addition to this obvious fact, the healthy cow is also responsible for many of the organisms found in milk, since, if care is not exercised, its habits and surroundings under which it is often kept tend to increase the bacterial content. In many cases the animals are confined to the cowshed for the greater part of the year and, being fastened in one place, have to feed, sleep, and perform their natural functions wherever they may be. Unless great care is exercised, they cannot avoid soiling their hindquarters and udders with dung and liquid filth. Long hairs on the udders and dirty flanks and tails all harbour organisms and, given the opportunity, the organisms found thereon readily gain entrance to the milk. It is therefore apparent that, in addition to healthy stock, clean animals are required. The entrances to the teats are small, but large enough to afford easy entrance for bacteria. Studies of the structure of the udder have been carried out by various investigators, and such have proved that there is no obstacle to bacteria finding their way by means of the milk ducts to regions remote from the teat.

It was thought at one time that milk drawn direct from the udder under aseptic conditions was sterile, but investigation has shown that milk, even after rejection of the fore-milk, contains a certain number of bacteria. The fore-milk certainly contains the greater number, but the middle-milk and the strippings are also frequently contaminated. It is apparent that the source of most bacteria found in the teat and in the fore-milk exists outside the udder. It is also established that, following milking, a column of milk remains in the teat passage. This milk provides a suitable breeding-ground for any bacteria obtaining entrance through the teat orifice. These bacteria, following a rapid increase in their numbers, find their way into the milk cistern and eventually spread throughout the milk tubes in the udder.

Milk may also be contaminated during *milking operations*. The bacteria which are introduced during this process are derived from three sources :

(1) From the flanks, hindquarters and udder of the cow.

(2) From dust in the air of the cowshed or milking shed, and from the milkers' clothing.

(3) From the person of the milker.

It is obvious that gross pollution of the milk may result from the conditions of the animal's flanks, hindquarters, and udder. In many districts it was once common to see animals whose flanks were plastered with partially dried manure to a greater or lesser extent. Unfortunately, this sight is still not unknown. Although the udder and teats do not usually show such obvious filth, they are frequently very dirty and display evidence of dried manure. The condition of a pail of clean water following its use for washing the udder of one cow only will clearly demonstrate the potential danger which exists. Manure is loaded with bacteria, and Orr has, by his experiments set out below, given striking proof of the number which may be reached.

	Sample.	No. of Organisms per gram. Agar 37° C.—48 hours.
Fresh manure which had been in the cowshed two hours only.	1	725,000
	2	3,500,000
	3	8,430,000
	4	1,258,000
Old manure cut from the hardened patches adhering to the flanks and udders of milking animals.	5	66,368,000
	6	185,000,000
	7	13,050,200,000
	8	8,649,300,000

It should also be remembered that it is the old dried manure which usually gains entrance to the milk. Wet manure shows more tendency to adhere to the animal, and so would not normally cause such pollution. The numerous bacteria contained in manure are chiefly organisms of the streptococcus and coliform classes. It is easy to understand that the tendency to pollution from this source will be greater in winter than in summer, when the animals are out in the fields for the greater part of the time, and when they consequently keep themselves in a more cleanly condition. Orr has also shown by a series of experiments how serious the pollution may become. A number of agar plates were exposed under the udder for two minutes each during milking operations and were then incubated for four days at 20° C. The number of organisms falling into the milk was calculated from the respective areas of the plates and the milking pails. The results of these experiments are shown in the table on page 148. It is obvious from this table that the proper cleansing of the animals' udders results in a smaller number of bacteria obtaining entrance to the milk.

The practice of the *milkers* coming direct from farm duties with dirty and dusty clothing is also to be deprecated, as such a practice presumes the addition of countless bacteria to the milk. The hands of the milker, especially one suffering from any disease, also add their quota. Although the hands may be washed and the udder and teats left untouched, the hands will soon become soiled, and much of this contamination, including as it may pathogenic bacteria, will find its way into the milking pail. Even when the hands and the udder are both properly cleansed, the friction induced by the

TABLE 5

Series.	Housing of Cows.	Condition of the Udders and Cows as regards Grooming.	No. of Experiments.	Average No of Colonies per agar-plate with 2 minutes exposure.
1	Summer—all cows out	Untouched	7	440
2	Do.	Udders and flanks brushed and washed	3	170
3	Winter—cows indoors	Untouched	3	4,752
4	Do.	Udders and flanks brushed but not washed . . .	3	1,752
5	Do.	Udders and flanks brushed and washed, but left moist .	6	230
6	Do.	Udders and flanks brushed and washed, but dried . .	3	444

process of withdrawing the milk from the udder may also add a certain number of bacteria to the milk. The absence of any head covering allows dust and scurf from the hair to fall into the pail, while the practice of many cowmen of milking with the head in close contact with the animal's flank is also a means of increasing contamination.

The *milking stool* is frequently handled during milking, and dirty stools will contaminate the milker's hands. Many producers appear to forget that the milking stool requires cleansing and sterilisation to the same extent as do milk containers.

As has already been shown, a source of frequent and often extensive contamination lies in the use of improperly cleansed and sterilised *milk containers*, such as churns, cans, and bottles. Tables have already been given showing the effect which such contaminated containers have on milk, and Savage quotes Harrison's experiments in this connection. In these experiments, containers were rinsed out with 100 ml. of sterile water and the numbers of organisms per millilitre estimated, the results being as follows :

Series A. 10 samples were examined from improperly cleansed cans and gave from 215,000 to 806,320 organisms per ml.

Series B. 10 samples from cans cleansed by washing with tepid water and scalding gave from 13,080 to 93,400 organisms per ml.

Series C. 5 samples from cans cleansed by washing with tepid water and then steamed for five minutes gave from 355 to 1,792 organisms per ml.

These results further emphasise what has already been stated regarding the inefficiency of attempting sterilisation without the use of steam.

Several other utensils besides churns and milking pails come into contact with milk during its progress from the cow to the consumer. Most important of these is probably the *strainer*. The straining of milk is universally practised throughout the country immediately after milking, and dirty strainers will considerably increase the bacterial content. Absence of any *cooling arrangements* is also certain to result in an increase in the number of bacteria present. On the other hand, coolers may themselves be an aid to contamination. They may be used or stored in dusty places, or their surfaces may not be properly cleansed or protected after cleansing from dust. A leaky cooler which allows water to gain access to the milk may cause pollution as well as adulteration. Experiments conducted by Orr have shown that dirty milk coolers may cause a serious increase in the number of organisms present. The results of these experiments are shown in Table 6.

TABLE 6

Experiment.	Condition of Milk.	Agar—37° C. 48 hours.	Gelatine—20° C. 96 hours.
A	Not cooled Cooled	36,000 53,000	43,000 78,000
B	Not cooled Cooled	12,000 31,000	14,600 129,000
C	Not cooled Cooled	20,000 32,500	25,500 49,000
D	Not cooled Cooled	37,750 77,000	76,000 162,000

The employment of *milking machines* may, if such apparatus is improperly cleansed, cause serious pollution. These machines should never be installed unless steam or hypochlorite solutions are available for their sterilisation. As an instance of the damage which may be caused by improper cleansing, the following figures taken from original tests give the bacterial content of milk samples before and after the proper cleansing and sterilisation of a machine by steam.

TABLE 7

Sample No.	Total Bacterial Count per ml.	Bacillus coli present in :	Remarks.
1	624,000	0.001 ml.	Before proper sterilisation.
2	800,000	0.0001 ml.	Before proper sterilisation
3	12,000	Negative	After proper sterilisation.
4	2,000	Negative	After proper sterilisation.

Samples Nos. 1 and 2 were taken during the period when the various parts of the machine were uncoupled and cleansed at weekly intervals, the pollution being chiefly due to an accumulation of slime in the teat cup. The methods of this producer were excellent in every other respect.

Quite apart from the apparatus used, conditions appertaining in the *cowshed* itself may have a detrimental effect upon milk so far as bacterial contamination is concerned. Dusty floors, the frequent use of hay and other dusty feeding-stuffs, and want of proper ventilation all assist in the pollution of the milk. Orr exposed agar plates in cowsheds for five minutes during milking with the following results, adjusted to show the numbers of bacteria falling on the surface of a twelve-inch pail :

A—3,456 and 3,600.
B—4,500.
C—3,375 and 4,185.
D—1,260.
E—2,068 and 2,700.

In view of these experiments it will readily be understood how open churns or pails containing milk and standing in the cowshed for some time prior to removal supply a certain means of polluting the product.

Following production, milk may be further contaminated during its *journey* from the cowshed to the distributor or to the consumer. Such contamination is difficult to estimate owing to the increase in the number of bacteria from outside sources being obscured by the increase due to the multiplication of those already present in the milk. Ventilated churns travelling in dusty vans, want of cooling prior to despatch and similar practices are all possible sources of pollution. Speedy transport of the milk from the producer to the distributor is essential, and should always be carried out under hygienic conditions. This presents little difficulty when the milk is transported in bulk or when large numbers of churns are sent in properly constructed vehicles. In many instances, however the consignments consist of two or three churns from small producers, generally unsealed and which have been left standing for considerable periods on roadside platforms. It must be emphatically stated that, at the present time, methods of transport leave much to be desired and form the weakest link in the chain of clean milk distribution. Further consideration of this important matter is given on pages 192 to 197.

The *distributor*, by the use of dirty utensils and dirty bottles, can add considerable contamination to what may originally be clean milk. The position of the retailer is made easy if he purchases milk from a farmer who is careful in his methods, but it can be rendered difficult if the milk purchased by him is contaminated when he receives it. If the producer is supplying a clean article it is the duty of the distributor to take every care and to protect the milk from contamination during storage and delivery. The method of delivering milk from churns and cans is a questionable proceeding, although it is still practised to a large extent in many parts of the country and remains a frequent source of pollution. The exposure of milk in basins, as seen in many milk shops even at the present time, is also a practice which should be discouraged. Although the basin may stand in a so-called sealed cabinet, this is not sufficient to prevent pollution from the atmosphere or tainting from the conglomeration of smells which abound in many general shops. In this connection Orr has proved that the average increase in the bacterial content of milk stored in shop premises other than in bottles, is 22·7 per cent.

The *consumer* is not always free from blame for the contamination of milk. Dirty receptacles and unsuitable storage places aid in the multiplication of the bacteria present and also add a fresh quota. The practice of leaving milk uncovered to be further contaminated by flies is still all too common, and, everything considered, there can be little doubt that much milk receives its initial contamination in the home.

Methods Necessary for Clean Milk Production

The producer must first of all ensure that his *animals* are free from disease and in a thoroughly healthy condition. Any beast suspected or showing signs of ill-health should at once be isolated from the herd, and its milk should never be mixed with the general supply. This milk, moreover, should not be fed to pigs or calves unless it has previously been boiled.

The condition of the *cowshed* should receive special attention. A good, well-constructed cowshed is an undoubted inducement towards the production of clean milk. When a cowshed is easily cleaned, well-lighted and ventilated, and has a good and sufficient water supply, less labour is required and the milkers take more care and interest in their work. The result in every case is cleaner milk. The animals are also healthier and, as the result of modern standings and yokes, they maintain themselves in a more cleanly condition and are easier to groom.

It is certainly possible to produce clean milk in an old cowshed if sufficient care is exercised. Mattick gives the following table showing the results of the bacteriological examination of milks produced in an old, unsatisfactory cowshed. These results show what can be done if sufficient care is taken in production methods.

TABLE 8

Sample No.	Age in Hours.	Temperature when Tested.	No. of Organisms per 1 ml.	Presence or Absence of B. coli.
1	5	50° F.	270	Negative
2	5	54° F.	510	Negative
3	5	50° F	430	Negative
4	5	50° F.	520	Negative
5	5	54° F.	1,250	Negative
6	6	53° F	820	Negative
7	8	55° F.	1,140	Negative
8	8	53° F.	400	Negative
9	5	54° F.	1,160	Negative
10	7	60° F.	930	Negative

As a further instance of what can be achieved by attention to method, the results of the examination of samples of milk produced in the old cowshed illustrated in Fig. 9 on page 74 are set out below.

TABLE 9

Sample No.	Sample No.	Total Bacterial Count per ml.	Bacillus coli present in :
1	112	8,400	0·1 ml.
2	177	4,020	1·0 ml.
3	28	62,900	0·1 ml.
4	93	61,000	1·0 ml.
5	132	16,000	1·0 ml.
6	156	15,600	Negative
7	35	15,200	1·0 ml.
8	61	33,500	Negative
9	88	21,300	Negative
10	129	26,000	Negative
11	7	25,500	Negative
12	41	8,200	1·0 ml.

The samples enumerated in the above table were in each case taken directly from the roundsman during the course of delivery, were approximately six hours old, and had a temperature of 60° F. when examined. No tubercle bacilli were found in any of the samples tested. The results were entirely due to proper and careful handling, with attention to detail. A word of warning is, however, necessary. These results, good as they are, should not be taken as an advocacy of such a type of cowshed, but there is no doubt that, with an old building and inexpensive appliances, much better milk could be produced than is at present too often the case.

The essentials of a good cowshed and methods of reconstruction have already been dealt with, and it is now only necessary to consider the cleansing of the animals and the other measures essential in the cowshed for clean milk production. It is not necessary to clean out the cowshed prior to milking when the animals are lying in, always provided that they cannot tread in the dung, but all manure should be pulled or scraped away from the animal and the standing brushed before the cow is cleaned. Dusty foodstuffs should never be given to the animals for at least one hour before milking takes place, owing to the amount of dust which will circulate in the air and so gain access to the milk. Dustless concentrates, which keep the animal occupied and quiet while milking is in progress, may, however, be allowed immediately prior to the commencement of this operation.

There will always be a certain amount of *dust* in the air, and it is important that this should be laid prior to the commencement of milking. This can be done in either of two ways :

(1) By the use of an ordinary watering can with "rose" attachment.
(2) By means of a hand-spraying machine.

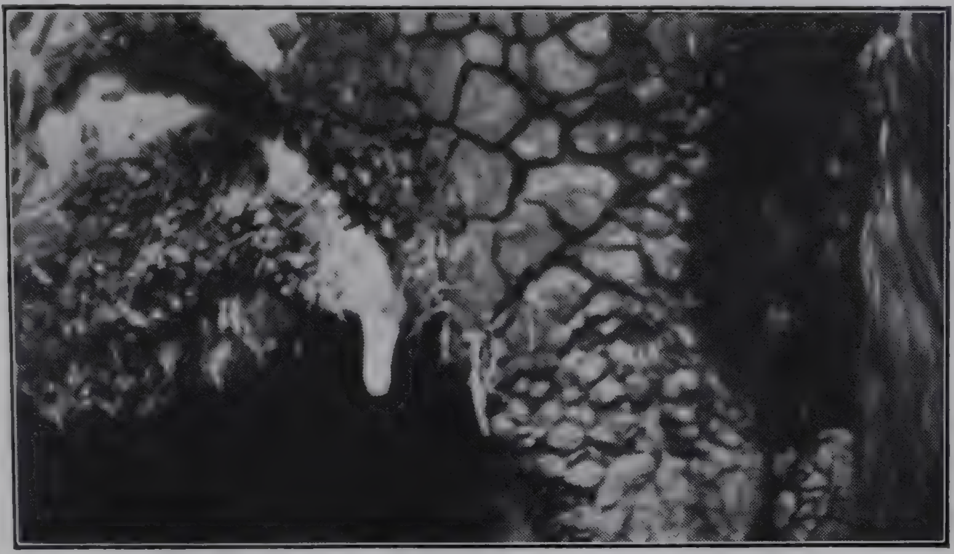
If the first method is adopted, the watering can is swung backwards and forwards in front of the person carrying out the operation. By this means, the standings, gutters, and walks are sprayed in some five minutes. For a shed of 40 cows, six gallons of water would be required. Spraying by means of a machine is more thorough, as the liquid is pumped and, with a fine spray, will carry well into the air and fall not only on the floors but also on the animals. In falling the fine particles of moisture assimilate dust from the air and carry it down to the floor. This operation requires approximately ten minutes, and nine to ten gallons of water are necessary for a cowshed containing 40 animals. It is advisable to add a little disinfectant to the water, as this tends to discourage flies. The walks, standings, and gutters should be washed at least once daily with water, following sweeping. Sweeping without a subsequent washing down is of little use, as this does not leave the floor really clean. The drains should also be flushed daily.

Limewashing should be carried out as frequently as is necessary and not according to law. With modern spraying machines the work can be executed quickly and efficiently, and care should be taken to ensure that the under surface of the roof is not forgotten. With frequent limewashing the shed is lighter and smells more sweetly, while the fly nuisance tends to be reduced. Walls should always be brushed prior to limewashing and a little disinfectant should be added to the limewash on each occasion.

No *bedding* or *litter* should be provided during summer months when the cows are out in the fields. It is advisable, however, to place a little straw along the gutter during this period, as this practice prevents splashing and expedites removal of the dung. No fresh bedding should be placed on the standings until milking has taken place. Some half an hour prior to milking, the clean portion of the bedding should be pushed forward to allow damping down of the rear portion of the standing.

The cow, owing to its habitant, tends to become very dirty, and produces both milk and manure with equal facility. Clean milk cannot be produced unless the two are kept apart. For some reason producers occasionally object to *grooming* their cows, although such farmers almost invariably perform the same function meticulously with respect to their horses. It is not essential that every particle of manure should be removed from the flanks and tail of the animal, but such parts must be reasonably clean. With unsatisfactory floors and standings animals are unable to keep themselves clean, while, with manure-littered approaches to the cowshed, the same applies. If the cowshed and yard are up-to-date no difficulty will be experienced in the ordinary course of events. Manure-caked animals, although not so common to-day as formerly, are still to be seen in large numbers. If the flanks and hindquarters of the cow are very dirty, it will take more than one day's work to remove the accumulation. In such a case it is advisable to clip off the dung and the hair together by means of hand clippers, which should be part of the equipment of every clean milk farm. It is also advisable to clip part of the flanks and the hindquarters, particularly those parts adjacent to the udder, especially during the winter months. The tail but not the switch should be clipped at least once every six weeks. This can be done in five minutes. Mechanical clippers may also be used but whatever type is employed, speed of action is of the greatest importance.

The hair on the udder, which is longer in some breeds than in others, harbours much dirt, which will contaminate milk during the milking process. This hair should always be removed, either by singeing or clipping, as the udder cannot be properly washed unless this is done. The time necessary to carry this out is approximately ten minutes.



By courtesy of the United Dairies Ltd.

FIG. 73. Dirty Flanks and Udder.

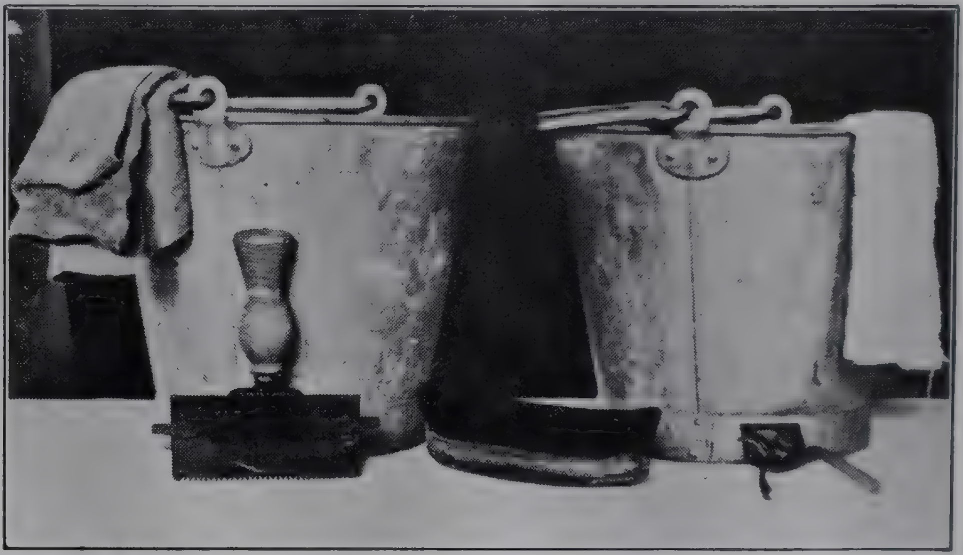
Mattick gives the following table to demonstrate the influence which clipping of the udder and washing and grooming of the cow exerts upon the bacterial content of milk. It is obvious, from the results obtained, that this procedure should always be followed.

TABLE 10

Conditions of the Experiment.	No. of Experiments.	Average Number of Bacteria per ml. of Milk.
Buckets washed and steam sterilised. (Cows ungroomed, udders NOT clipped.)	30	Open Pail—4,274 Covered Pail—1,505
Buckets washed and steam sterilised. (Cows' udders clipped.)	51	Open Pail—2,505 Covered Pail—516
Buckets washed and steam sterilised. (Udders clipped, cows washed and dried.)	42	Open Pail—900 Covered Pail—388

Many producers exhibit a strong prejudice against clipping the udders and hindquarters of their animals, alleging that they are liable to suffer from cold and become subject to many and diverse diseases. This objection has not been borne out in practice, particularly if this procedure is commenced during the warmer months of the year, although it is not advisable to clip the udders of newly calved cows for at least one week after calving.

Once the animal is clean, it is an easy matter, by means of regular routine before milking, to maintain the same satisfactory condition. The cow's flanks, tail, and udder should first be groomed with a curry comb, and then thoroughly brushed with a stiff brush, slightly damped. The time taken to carry this out is approximately five minutes per animal. The flanks and tail should then be thoroughly washed in water to which a little disinfectant or hypochlorite solution has been added. The tail switch should first be soaked in the pail and then thoroughly shaken out. Two pails are required for washing purposes, one of which is kept for the udder and the second for the flanks and tail. A plentiful supply of clean cloths is necessary, together with numerous pieces of rough towelling for drying off. In some cases it may be found necessary to give the animal a preliminary rough washing for the purpose of removing excessive filth, a separate pail being used for this purpose. In severe weather the water should preferably be tepid to prevent chilling the animal, although many clean milk producers use cold water for washing purposes, even direct from a hosepipe, with no apparent ill-effects. The employment of water at a temperature of between 130° F. and 140° F. is said to stimulate the flow of milk and save hand stripping in cases where machine milking is practised. The use of water at such temperatures might be advantageous where hard milking cattle are concerned as it will encourage cows which tend to withhold their milk to let down the liquid without difficulty. The addition of hypochlorite solution to the washing water is to be recommended, the cloths being dipped in this solution for final treatment. A strength of 800 parts per million should be used and the solution should be renewed after treating each eight animals.



By courtesy of the United Dairies Ltd.

FIG. 74. Utensils required for Cleansing and Washing Animals.

It is not desirable that the animals' flanks or udders should be thoroughly dried after washing as, if they are left damp, any dirt which may remain on these parts is prevented from falling into the milk. It is, of course, essential that the flanks, etc. should not be left so damp as to allow water to drop into the milk during the process of milking. The cleaning and washing of the animals should be completed at least fifteen minutes before milking commences. During the washing process frequent changes of water are necessary.

The most important part of the cleansing operations is the *washing of the udder and teats* prior to milking, and particular care should be taken with the teat orifices and the clefts between the quarters of the udder. Many producers are averse to washing the udder, as they are of the opinion that such washing causes " chapped " and sore teats, and is thus detrimental to the cows. Authoritative veterinary opinion does not uphold this view and, as many farmers are already carrying out this practice without any ill-effects, it would appear that this adverse opinion is without foundation. The appearance of the water in the pail after being used for washing two or three udders will satisfy anyone as to the need for this procedure.

The importance which should be attached to such washing by all producers who aim at producing clean milk is illustrated by the experiments of Skelton who obtained the following results, showing the effect of washing the udder on the bacterial count of samples of milk.

FOUR EXPERIMENTS ON THE WASHING OF A COW'S UDDER

Udder Washed	*Udder Unwashed*
530 bacteria per ml.	3,000 bacteria per ml.
300 bacteria per ml.	1,300 bacteria per ml.
754 bacteria per ml.	800 bacteria per ml.
590 bacteria per ml.	1,100 bacteria per ml.

The operations already indicated may appear to entail an unnecessary amount of labour, but once the cows are clean and housed in a cowshed whose construction assists in retaining this cleanly condition, it will be found that the work can be completed in a comparatively short time. A skilled worker can easily carry out all operations necessary on each animal within five minutes. *It should, however, be noted that, unless these operations are carried out at least once daily, they cannot be completed in the time stated.*

The *personnel* responsible for the handling and care of the animals play a vital part in clean milk production. These are the owner, the cowman or cowmen who may or may not milk, and the actual milkers. On those persons depends the ultimate success of the methods used in production. As good methods and handling probably account for between 80 to 90 per cent. of the essentials required in the production of clean milk, those individuals assume an importance with which they are not always credited.

The *owner* or *producer* is of primary importance, as the whole routine of the cowshed depends upon his instructions. The producer is generally willing to be shown new methods and to put them into practice, provided no great expense is involved. He naturally wishes to know why certain methods are advised, and he must be satisfied on this point before making any move in the required direction. In many cases it is difficult to persuade farmers to change their views on milk production, but, by repeated reiteration of what is necessary, some of the instruction will be found to yield fruit although old theories handed down from father to son are difficult to displace. Producers can, of course, be driven to institute improvements by the use of such legal enactments as are provided, but it is always a bad policy to drive when a friendly lead will more easily attain the desired object. There is a big difference between the man who thinks in terms of producing the best quality possible and the man who is constantly striving to just " get by." The latter person constitutes a real menace to the dairy business, both from the point of view of economics and of disease control. The bad and deliberately careless producer will explain that the return does not pay him for the labour likely to be involved and so long as he does not add water to his milk, he is, for the moment, comparatively safe, no matter how poor the milk is as regards cleanliness. The result is that many producers set their own standard of milk which they will supply to their customers. Many producers err only through ignorance, while others have to suffer through the ignorance and carelessness of their cowmen and milkers. An instance of this which concerned a sample of milk produced within the area of a certain local authority might be stated. Bacteriological examinations gave consistently unsatisfactory results, and the producer, a capable man who thoroughly understood the methods essential for clean milk production, was at last forced to discharge his cowman for wilfully neglecting his duties. A new cowman was installed and no further unsatisfactory results were obtained. A bad cowman is one of the greatest stumbling-blocks to clean milk production. Some of the blame for dirty milk can certainly be allotted to the cows, but the man in charge of the animals must also share the censure. An up-to-date, careful cowman can, by his practical efforts, produce good, clean milk, but the dirty, unprogressive milker can seldom be made to understand the reason for care.

It should always be remembered that the *cowman's* task is not too easy although some reductions in hours and increases in rates of pay have taken place since the war commenced. Even now conditions on farms are more onerous and worse paid than on the distributive side of the industry. It is a hard life which has a certain bearing on the question of clean milk production as, if conditions are unsatisfactory to the worker and he is not encouraged by the owner, he will leave, and his position may be difficult to fill. Indeed, since the commencement of the war, labour has been an awkward problem for the producer to overcome and it is quite likely that clean milk production has suffered thereby. It is becoming increasingly evident that the industry is failing to attract or hold the better and more suitable type of worker. Where service is required on every day of the year, the worker cannot be blamed for seeking less exacting employment. Young men nowadays do not wish to learn to milk and have no desire to be employed as cowmen. The cowman is at work early in the morning and late at night. He may, of course, be given a break in the middle of the day, but this does not appeal so much as working straight through and finishing early. During the illness of any of the animals, the cowman may also be up for a greater part of the night on consecutive occasions. Cowmen have not usually had the advantage of a good education, and often they cannot readily grasp the fact that it is possible to have dirt in the milk which cannot be seen. Milk may be strained and they will understand the visible result, but such straining will never remove the contaminating organisms, although they appear to regard it as a panacea for all carelessness in their methods.

The *milkers*, who are generally members of the cowman's or other farm hands' families, are also for the most part ignorant on the question of contamination, even after the matter has been fully explained to them. It is a further remarkable fact that the man who is most careful with the animals is often the worst as regards clean milk production. Milkers can usually be encouraged to produce better results by an appeal to their pockets, that is, through the bonus system. If the cowmen or milkers realise that they are fined or rewarded according to the results of the examination of the samples taken, they will probably be more careful and work without the need for constant supervision. Below is given a scale of bonuses and fines which have been used by many producers of graded milks who were forced to produce milk of a certain bacterial standard.

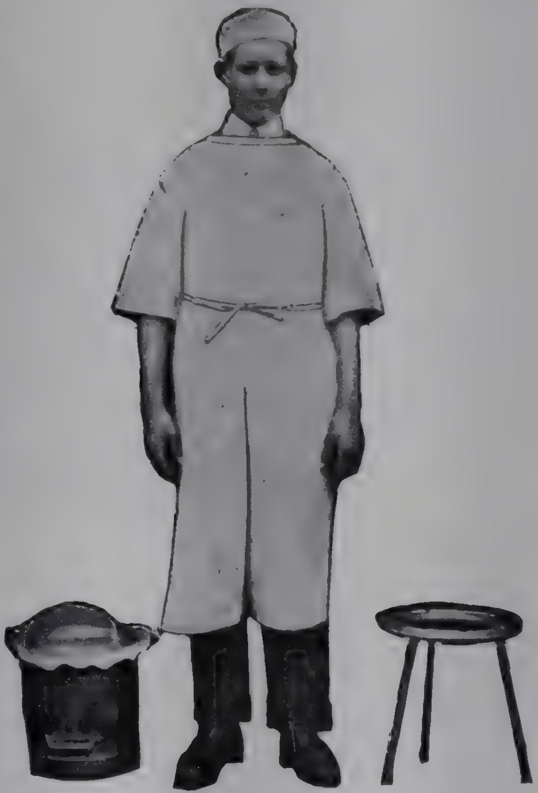
SCALES OF BONUSES AND FINES

Over 200,000 bacteria per ml.	Fined 6*d*. per week.
100,000 to 200,000 per ml.	No bonus —no fine.
30,000 to 100,000 per ml..	Bonus of 6*d*. per week.
5,000 to 30,000 per ml.	Bonus of 1*s*. per week.
Under 5,000 bacteria per ml.	Bonus of 2*s*. per week.

With the introduction of the methylene blue reduction test, the abovementioned bonuses based on bacterial counts cannot, of course, be paid, but there is no reason why bonuses based on repeated satisfactory samples should not be given.

It is particularly essential that the milkers should be healthy and free from any infectious disease. Illness affecting any of the milkers should be noted and medical attention immediately obtained. Mild cases of diphtheria, typhoid, and scarlet fever among those handling milk have resulted in extensive epidemics of those diseases. By calling in the aid of a medical man, the producer not only protects his customers but also protects himself, as he is liable to suffer a severe pecuniary loss if an epidemic results from the consumption of his milk.

The persons who milk the animals should not only be efficient milkers but clean workers and cleanly in person and habit. The employer should encourage his workers by precept and example. If this is not done, satisfactory results can hardly be expected.



By courtesy of the Dairy Outfit Co. Ltd.

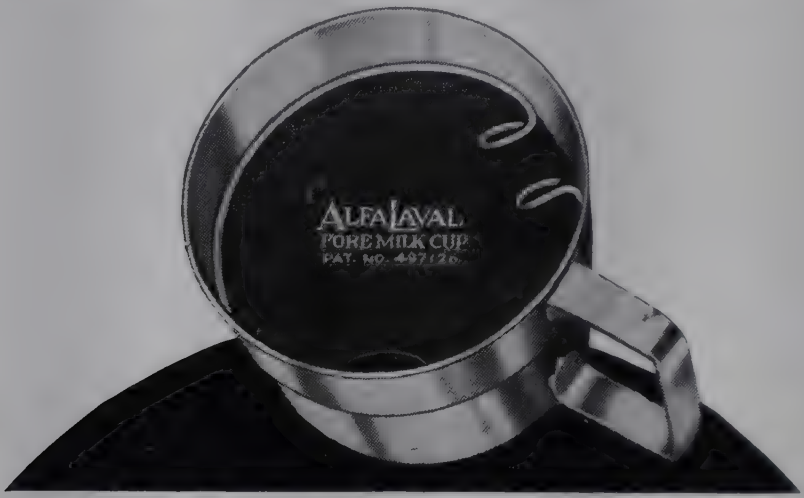
Fig. 75. “Covernee” Overall.

It is a strange fact that anyone, no matter how inefficient they may be, can engage in milking or other dairy work, and a measure of proficiency in all workers engaged in milk production is desirable. Courses of training for dairy employees should be instituted in rural areas and these could be carried on by travelling instructors. Certificates of proficiency might be awarded and, after a fixed period, all dairy workers should be required to hold such certificates before being allowed to assist either in milk production or distribution.

One cowman is required for every 20 cows, and, if hand milking is practised, one milker for every 10 animals.

As the milkers and cowmen are responsible for the washing and cleansing of the animals, *overalls*, which completely cover the knees of the wearer, should be provided for this purpose. These overalls should be removed prior to milking and a further supply of white overalls, two suits of which are required for each milker together with caps, should then be provided. These should be composed of washable material, a clean suit being necessary each week. The white overalls should be worn only when milking is in progress. They serve the double purpose of preventing contamination of the milkers' hands via his clothing, and also of fostering that spirit of cleanliness so essential in all workers interested in clean milk production. Caps for female milkers should completely cover the hair. The bathing cap type is generally preferred.

The milkers should thoroughly *scrub their hands and arms* before milking commences, while it is also essential that the hands should be washed after the milking of each animal. Soap should always be provided, and it is important that the washing accommodation should be situated in the cowshed or in the milking shed. Washing accommodation provided some distance away in the farm-house is not conducive to regular use, especially in the early morning. Clean towels should be provided adjacent to the washing accommodation, and these should be changed at least every two days, but preferably daily. The addition of hypochlorite solution to the washing water will be found advantageous.



By courtesy of Alfa-Laval Co. Ltd

FIG. 76. Strip Cup.

Before milking proper can begin, there is one very important operation which must be carried out. This is the *rejection of the fore-milk.* If the fore-milk is allowed to enter the milking pail it will considerably increase the bacterial content of the product. It has already been explained that bacteria may gain entrance to the teat orifice and the milk ducts of the udder by means of the teat canal, and, if the first two or three " draws " of milk from each teat in each quarter of the udder are rejected, a much smaller bacterial content of the final product is likely to result. This is very important, and should never be forgotten. The milk should be collected in a small pail and removed immediately from the cowshed, when it can be given to the pigs or calves. It is advisable that the safe disposal of fore-milk should be combined with a twice-daily inspection of the milk by using a " strip cup " with a view to the detection of animals affected with mastitis.

Whilst mechanical milking is on the increase, hand milkers are still in an overwhelming majority. This method deserves special mention as, generally speaking, the standard of milking leaves much to be desired. Poor *milking* does more to spoil good cows and lose money than anything else which occurs upon the farm. The milker should remember the following facts :

(1) Milk is retained in the udder by means of a muscle in the teat, which acts as a safety valve.

(2) The operation of milking consists of two simple actions, namely, the pressure and release of this muscle.

(3) The teat should be held by placing the fingers three-quarters of the way round and be pressed with the tips of the fingers against the palm of the hand.

(4) The whole operation should be carried out *from the wrists downwards* and the arms should not be brought into use at any time.

(5) Milking should be regular, steady, and sustained.

Wet milking, which is an abominable practice, is still to be found, more especially among the older milkers, who prefer it, apparently because the action requires less effort and is less tiring than dry hand milking. The usual practice is to allow the first few streams of milk to run over the hands, after which milking commences in real earnest. This practice will never result in the production of clean milk, and should be condemned. *Dry milking* is essential and, although the effort required from the wrists is greater than that necessary for wet milking, the arms and muscles soon become accustomed to the action. Experiment has shown that 5,000 bacteria per millilitre will be ejected with wet hands into a covered pail against 60 bacteria per millilitre with dry hands. Some producers object to dry-hand milking on the ground that sore teats result from this method, but these objections are not sustained in practice. Care should be taken to ensure that proper stripping of the animals is carried out at the completion of milking. The significance of this operation is not always sufficiently understood by the milkers.

Two further points should be attended to before milking commences, as follows :

(1) *General Quietness in the Shed.* It is advisable to speed up the preliminary work and also to take steps to prevent the animals becoming restive, so that milking operations may be more speedily completed.

To assist in retaining the animals in a more restful condition, especially during warm weather, they may be sprayed before milking with water from a hand spray in a similar manner to that used for the floors and walls. If a small amount of disinfectant is added to the water this will discourage flies, and will assist the milker to perform his work in greater comfort and with more speed. Some cows have an unfortunate habit of swinging their tails vigorously during milking operations with serious consequences to the milk, the tails of such animals should be fastened to their hind legs while milking is in progress. The proper handling of dairy cows is vital to clean milk production, and any noise or impatience exhibited by the milkers should be severely dealt with.

(2) *The prevention of undue draughts* which are liable to carry dust and dirt into the milk.

It is surprising how little attention is paid to the large amount of contamination which may be introduced into the milk by particles of dust from the atmosphere. The cowshed, milkers, pails, etc. may be ideal in design and efficiency, yet, in the presence of a strong draught, myriads of dust particles, invisible to the naked eye, may be deposited in the milk.

As previously stated, the cleanliness of the *milking stool* is quite as important as the cleanliness of any other article used in the production of clean milk, and it is an unfortunate fact that there are still too many dirty milking stools to be seen during cowshed inspections. If the milking stool is dirty, the hands of the milkers soon become contaminated with manure or partially dried milk, more particularly as the milkers' hands often come into contact with the stool. Stools should be washed and scrubbed at least once per day. They should, if steam is available, be sterilised after washing together with the other utensils. After treatment they should be stored in a clean situation until required for further use. Wooden stools are in commonest use, but there are many types of welded metal stool on the market which are to be preferred. Such stools do not suffer from any of the defects of the wooden variety, such as cracking, warping, or loose legs. A dirty milking stool will nullify all the washing of the milkers' hands between the milking of individual cows. Figs. 77 and 78 show satisfactory examples of wooden and metal milking stools.

Owing to the necessity for properly cleansing and sterilising the *milking pails*, whatever type is used, it is essential that such pails should be constructed of non-absorbent material. Wooden pails are still to be found in some districts, and these possess serious disadvantages. If warm milk is put into a dry wooden vessel, the heat of the milk will cause the air in the pores of the wood to expand, when a portion of the air will be driven out. As the milk and vessel cool, milk is drawn into the wood to replace the air previously expelled. When the milk has entered the wood it is a very difficult matter to remove all traces, and that portion which remains provides suitable pabulum for the growth of bacteria. This suction can be prevented by soaking the wooden vessels first in hot water and then in cold. Even with such treatment wooden pails cannot be considered satisfactory, and all vessels should therefore be constructed of metal, with well-tinned surfaces and properly constructed joints. An absence of corners is also advisable, so that all parts of the pail may be easily accessible for cleansing purposes.

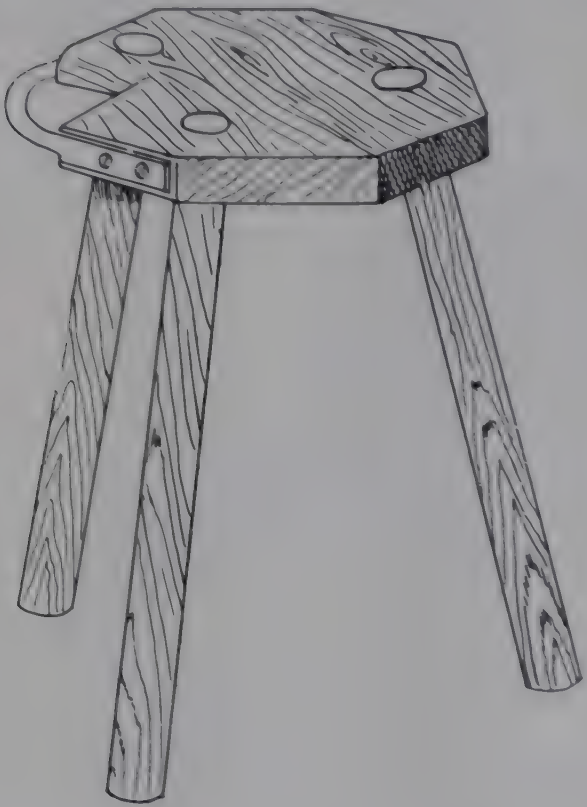
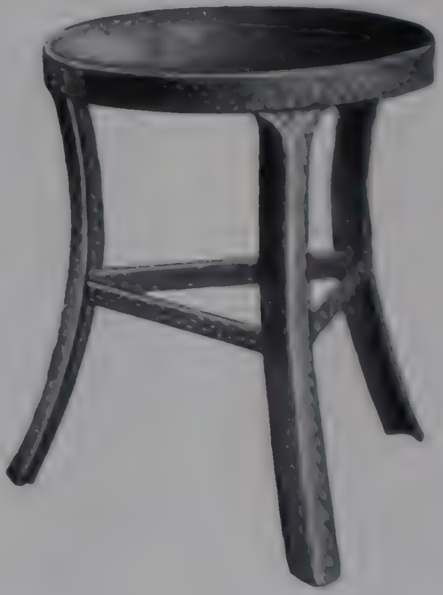


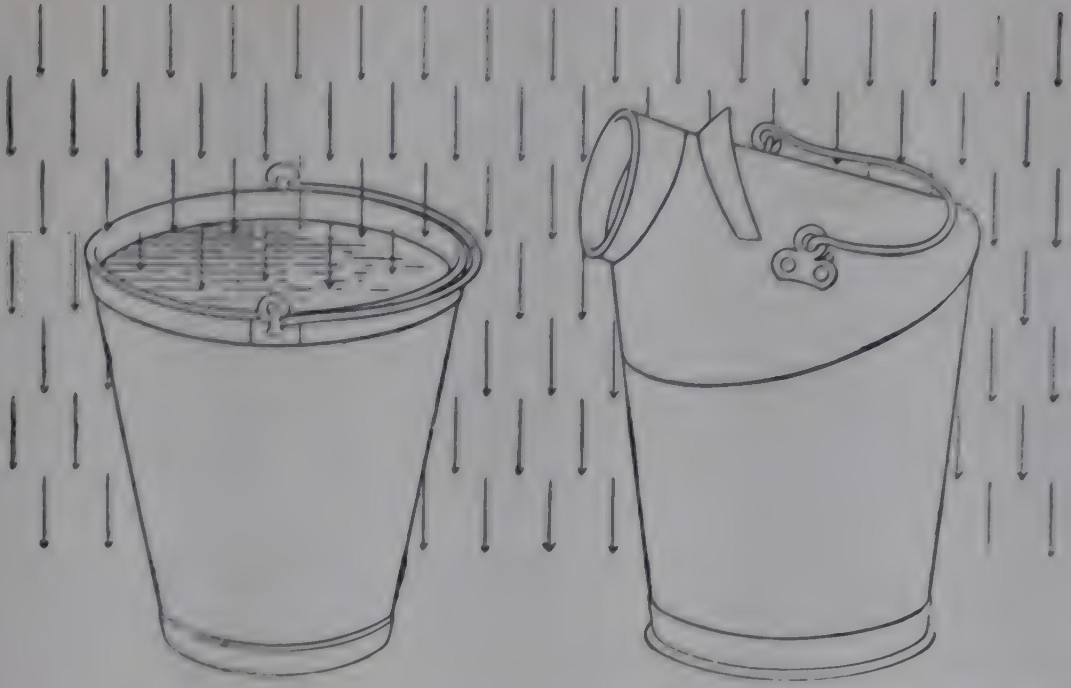
FIG. 77. "Whitecourt" Wooden Milking Stool.



By courtesy of Wessex Supplies Ltd.

FIG. 78. Galvanised Metal Milking Stool.

There are still more open-top milking pails in use than those of the covered variety. The commonest type of pail met with to-day is widest at the mouth, to allow easy access for the milk. The use of open pails cannot be recom-



By courtesy of the National Milk Publicity Council.

FIG. 79. Mode of access of contamination in milk pails and prevention by the use of a covered pail.
(Arrows represent falling dirt or dust.)

mended, as any droppings from the udder and the flanks and tail of the animal or any dust from the air of the cowshed can easily find their way into the pail and so into the milk during milking operations.

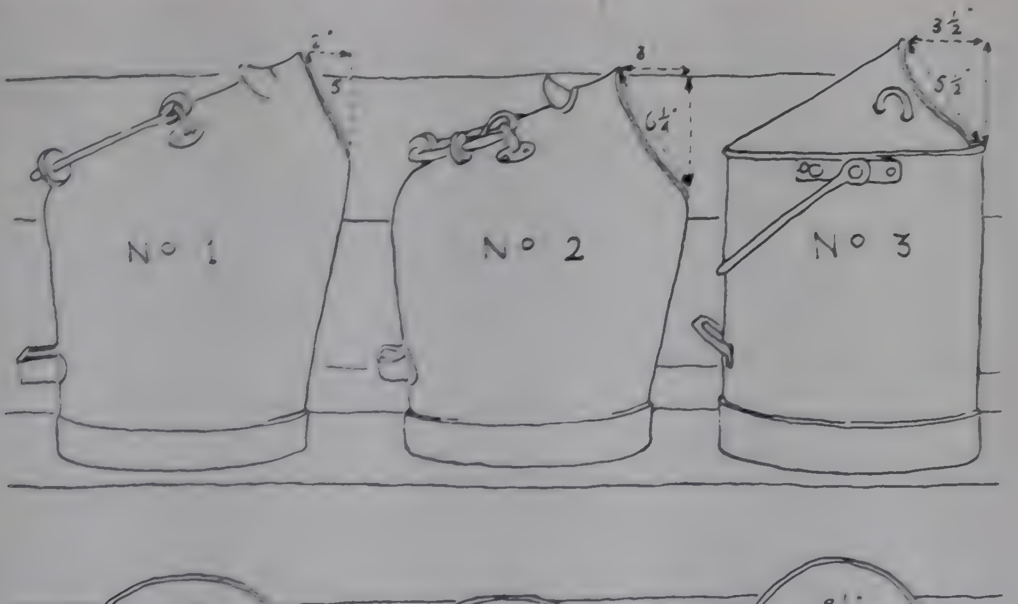


FIG. 80.

Reproduced by permission of the Controller of His Majesty's Stationery Office from Research Monograph, No. 1, Ministry of Agriculture and Fisheries—" Studies Concerning the Handling of Milk, 1925.

Table 11 illustrates the advantage to be gained from the use of covered pails, the modern type of which is illustrated. These results were obtained following experiments carried out by Hickson at the National Institute for Research in Dairying, Reading, which was probably the first institution in the country to use covered milking pails, of which only one type was then in existence.

The types of covered pail shown in Fig. 80 were used in the experiments in question.

The use of the *covered pail* cannot be too strongly recommended. Its size may vary as requirements dictate. It is essential, however, that the opening should be as small as is practicable, and should be approximately vertical, thus presenting a minimum area through which dirt may gain entrance. The size of the opening varies from 4 to 8 inches as compared with the 12-, 14-inch or even larger opening of the open pail. Some covered pails are made with removable covers. This type is not to be recommended as the milkers may omit to fit the cover or, what is even more serious, may place the cover temporarily upon the floor, thus increasing instead of decreasing the risk of contamination. Some initial difficulty in the use of covered pails may be experienced by the milkers owing to the effort required in directing the stream of milk from the teats into the opening, but such a difficulty is quickly overcome. Whichever type of pail is used it should be constructed in one piece without seams to harbour dirt, should be well-tinned and soldered or constructed of stainless metal of three gallons capacity, and should permit of easy cleansing.

TABLE 11 [1]

	No. 1.	No. 2.	No. 3.	Open.
Size of Opening. Set Back.	7 × 5 in. 2 in.	8 × 6 in. 3 in.	6½ × 5½ in. 3½ in.	
Number of bacteria . . .	1,520	1,310	1,150	6,420
	1,290	1,270	1,070	2,350
	1,170	840	980	2,280
	770	780	860	1,690
	440	710	830	1,670
	430	690	820	1,420
	400	450	440	1,310
	310	340	380	1,010
	240	290	330	450
	220	210	130	240
Total bacteria per ml. . .	6,790	6,890	6,990	18,840
Average per ml. . . .	679	689	699	1,884
Reduction of organisms as compared with open pail . .	64%	63·4%	63%	—

It will be observed, from the bacterial counts set out in the above table, that the three types of covered pail are approximately equal in value.

One proprietary type of pail deserves special mention, as it is of novel design. This pail is fitted with a removable filter. It is heavily constructed, entirely seamless and a new filter can be fitted prior to each cow being milked. The filtering medium is spring loaded to grip the aperture of the pail top.

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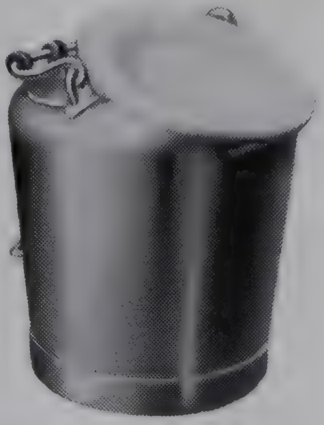
[1] Table reproduced by permission of the Controller of His Majesty's Stationery Office from *Research Monograph*, No. 1, 1925—*Studies Concerning the Handling of Milk*, Ministry of Agriculture and Fisheries.

It should be remembered that in many parts of the country, where scattered grazing grounds are common, it is the producers' habit to milk in the fields, particularly during the summer months. This practice has nothing to recommend it as the milk is particularly liable to pollution, while delay in cooling is certain to assist in the rapid increase of the initial bacterial content. Producers say that this method allows the animals to stay in the open air, in many instances all the year round, and as a result they keep cleaner than would normally be the case. If animals are kept in this manner milking sheds or bails should always be provided. So ingrained is the habit that it is difficult to check. In such districts the custom of storing milking pails and strainers under the nearest hedge should not be countenanced under any circumstances.

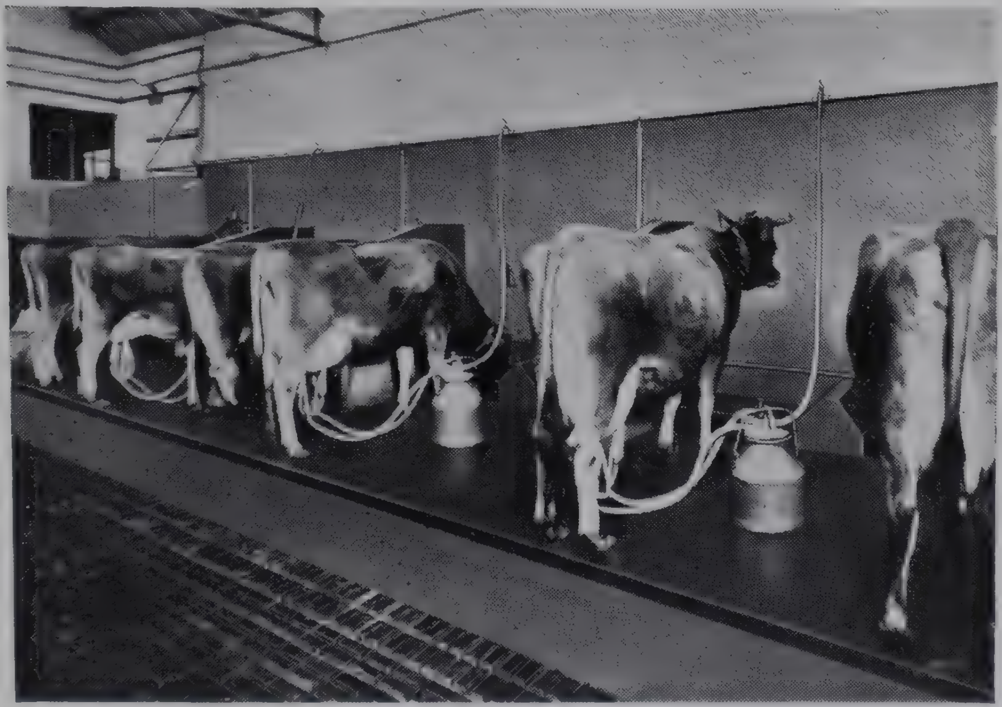


By courtesy of Clare's Service.

FIG. 81. "Wessex" Clarfilter Pail.

Milking Machines

The interest which has been taken by many farmers in clean milk production and the prevalent shortage of labour has led to a more general use of milking machines. At present it would appear that Great Britain lags far behind the United States, the Continent, and New Zealand in the use of these devices, it being estimated that only one home farm in twenty-four is so equipped, while approximately three-quarters of the farms in New Zealand are supplied with the necessary machinery. The milking unit is probably the only contrivance in existence which harnesses a power machine to an animal and if the labour-saving advantages were

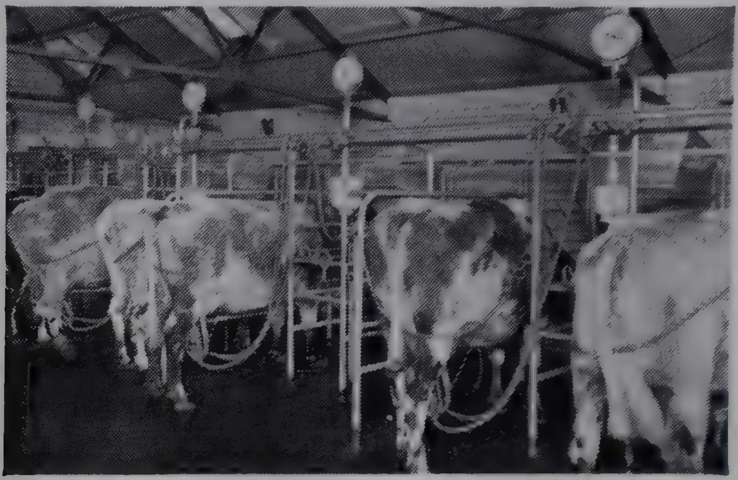


By courtesy of Alfa-Laval Co. Ltd.

FIG. 82. Alfa-Laval Bucket-type Milking Machine.

more fully realised there would probably be a rapid increase in the number of machines installed. Advisory work in connection with production has been almost wholly based on hand milking. While the supervision of this practice is important, a more progressive outlook on the part of those responsible for this work might have produced an earlier and wider adoption of milking machines which, with proper instruction and care, would have enabled the readier production of more and better milk.

The difficulty experienced in obtaining skilled milkers has already been mentioned, and this difficulty is one which is more likely to increase than to decrease. Farmers have naturally been seeking some way of overcoming this obstacle, and those who are keen on clean milk production are consequently installing milking machines. Apart from assistance afforded in the production of clean milk, there is also a reasonable ground for contending that the uniformity of mechanical milking results in a higher milk yield, but it must be pointed out that no mechanical milking can be absolutely uniform unless positive control is fitted to ensure that the pulsators on every unit operate regularly and at the same speed.



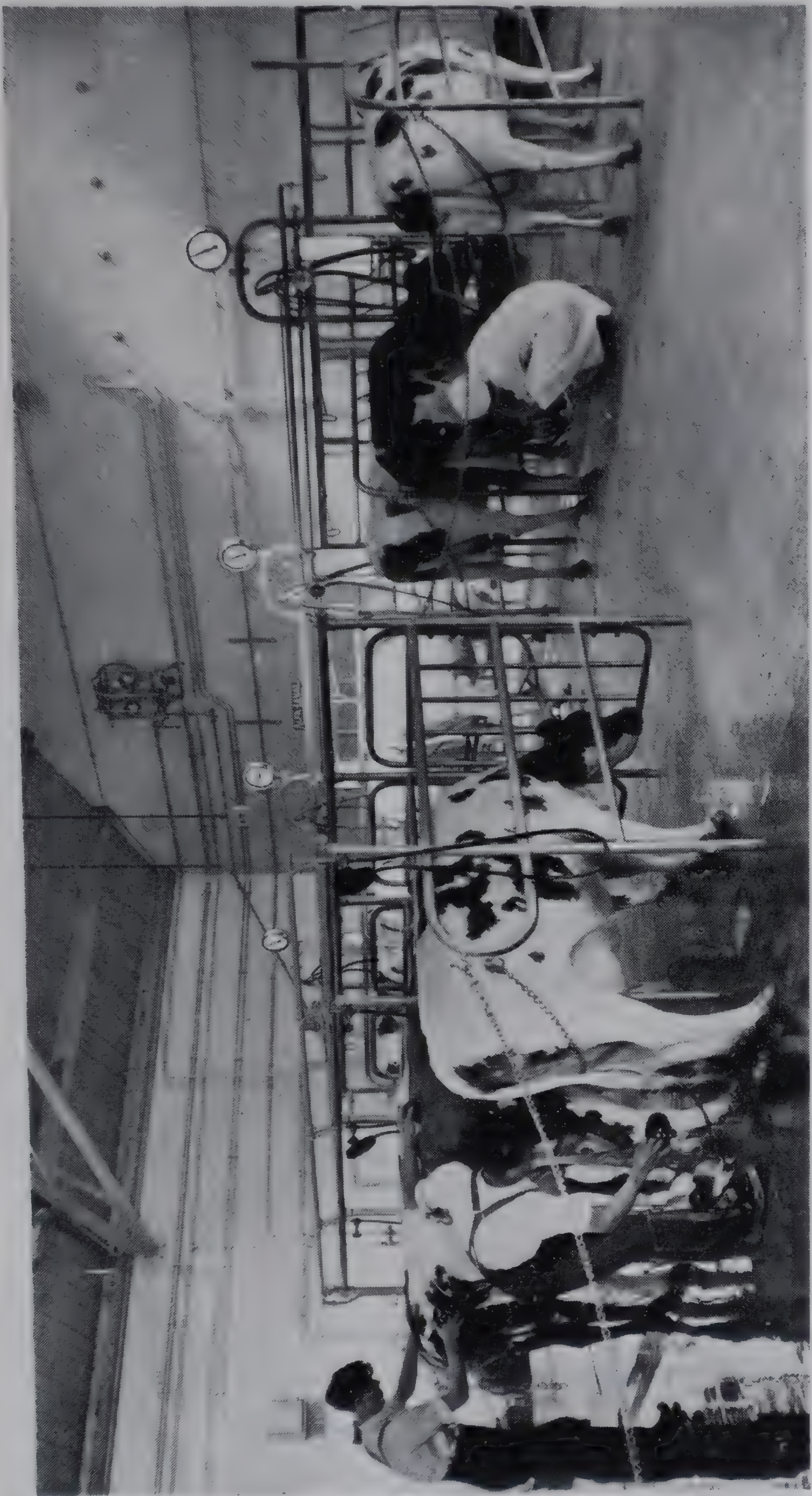
By courtesy of Alfa-Laval Co. Ltd.

FIG. 83. Alfa-Laval Combine Recorder.

Milking machines are not a new development in this country, but the machines of ten to twenty years ago failed chiefly on the score of milk contamination and unsatisfactory action. Nothing can contaminate milk more quickly than an improperly cared-for milking machine. The older types of apparatus were intricate in operation and difficult to cleanse, and could not be recommended as an aid to clean milk production. Subsequent improvements in design have concentrated on these points with complete success, always provided that the machine is properly used and cleansed. The newer types of units involve the minimum area of surface in contact with the milk, and are designed to give ready access to all such surfaces for cleansing. They also endeavour to eliminate the presence of any crevices or pockets in which dirt may accumulate.

The suspicion attached to the use of milking machines in this country is gradually passing, following the experiences of many producers of clean milk, together with their successful application in other countries. They possess certain apparent advantages, in that no dirt from the cow can enter the pail, while, if properly handled, the possibility of contamination of the milk from the milker's hands or from the air is avoided. Their simplicity in operation and mechanical efficiency also appeal to many farmers.

In perfecting such apparatus, engineers have made what is perhaps the greatest single contribution to a high-grade milk supply yet attained. The constructors of the machines studied the action of the calf in extracting milk from the udder of the cow, and proved, among other things, that the action of hand milking, which applied pressure only, was not so satisfactory as that of the calf, which withdrew the milk from the udder by pressure and suction. In the older type of machine the suction was too strong and exhausted the



By courtesy of Alfa-Laval Co. Ltd.

FIG. 84. Alfa-Laval Combine Recorder. (Note separate washing stalls.)

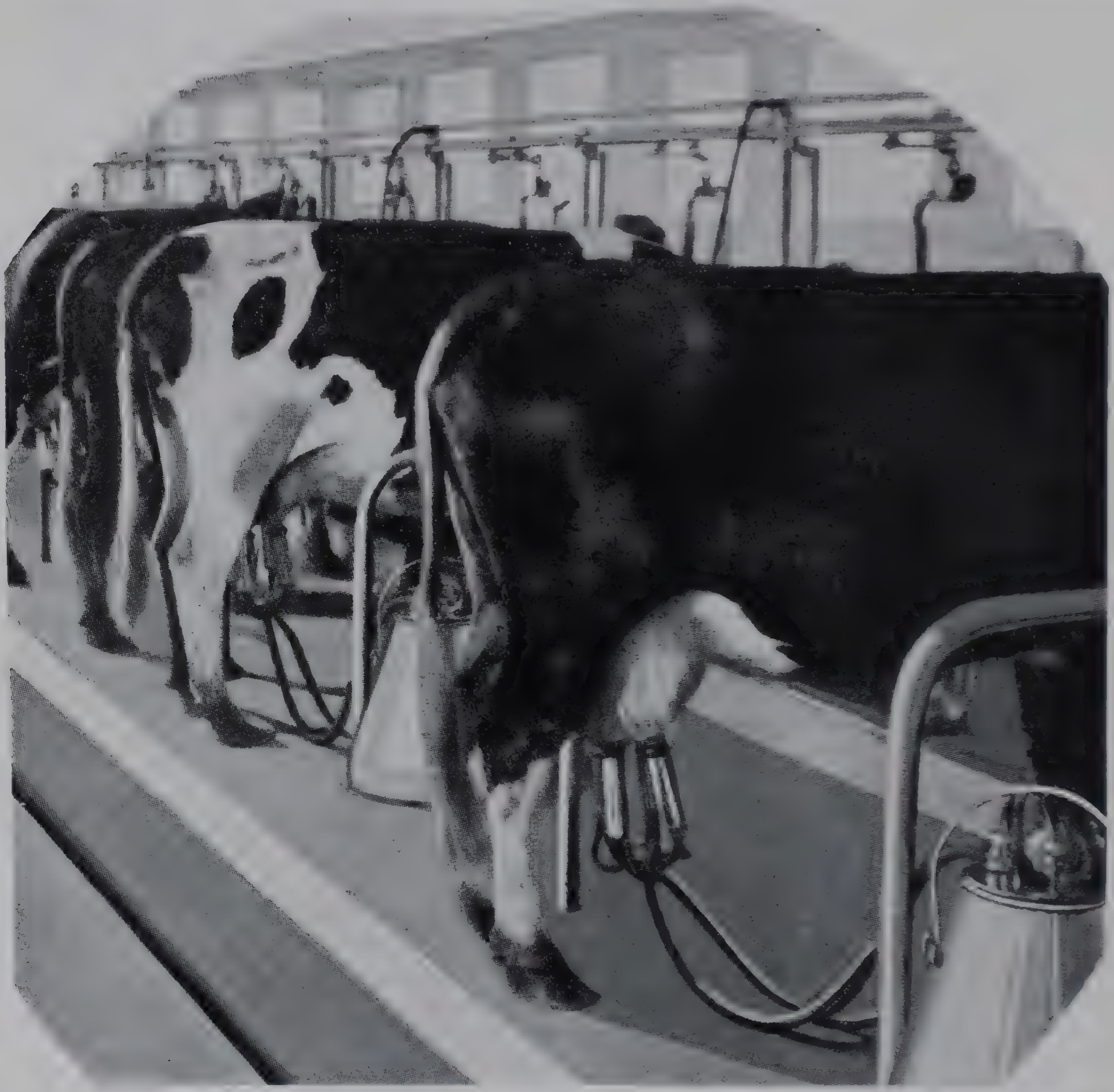
udder to such a degree that, if the machine were not carefully controlled, traces of blood were found in the milk. The action of the modern machine has been modified to cure this defect, and is a combination of suction, pressure, and release, designed to imitate the action of the calf without any lubricant.

Two definite advantages are claimed for the modern milking machine. These are :

(1) Cleanliness of the milk.
(2) Saving of production costs.

Both of these advantages will make a strong appeal to the modern milk producer.

Perfect adjustment has been obtained in the latest types of machines, so that it is possible to transmit milk direct from the cow to the churn entirely untouched by hand and free from air-borne contamination. The saving in labour costs is largely a matter decided by the size of the herd, but, as a general rule, little advantage may be gained from the use of a machine unless the herd consists of at least 30 cows in milk except cleanliness in production. It may be assumed in practice that a herd of 30 to 35 cows can be machine-milked by two men or one man and a boy with three units in one to one and a quarter hours. To perform this by hand in a similar time would require four milkers, while two milkers only would require from two to two and a half hours to carry out comparable work. The saving in labour costs is not,



By courtesy of the International Harvester Co. of Gt. Britain Ltd.

FIG. 85. "McCormick-Deering" Milking Machine.

however, so great in practice as it appears in theory. Extra labour has to be expended on all parts of the machine in cleansing and sterilisation, as all tubing, teat cups and receivers require to be dismantled, washed and sterilised after each milking. As there is no intimate contact with the udders of the animals such as takes place when hand milking is practised, it is necessary to make a careful daily inspection with a view to discovering any incipient signs of udder disease which would probably otherwise escape the attention of the machine operator. Otherwise, udder infections may quickly spread throughout the herd. For those reasons the reduction in labour is diminished to a certain extent, and is not so great as would be the case if milking only was the aim of the producer. Farmers installing machines would do well to remember that the care of the machine is an essential part of the routine, and that any lowering in production costs by the neglect of this precaution constitutes a highly dangerous form of economy.

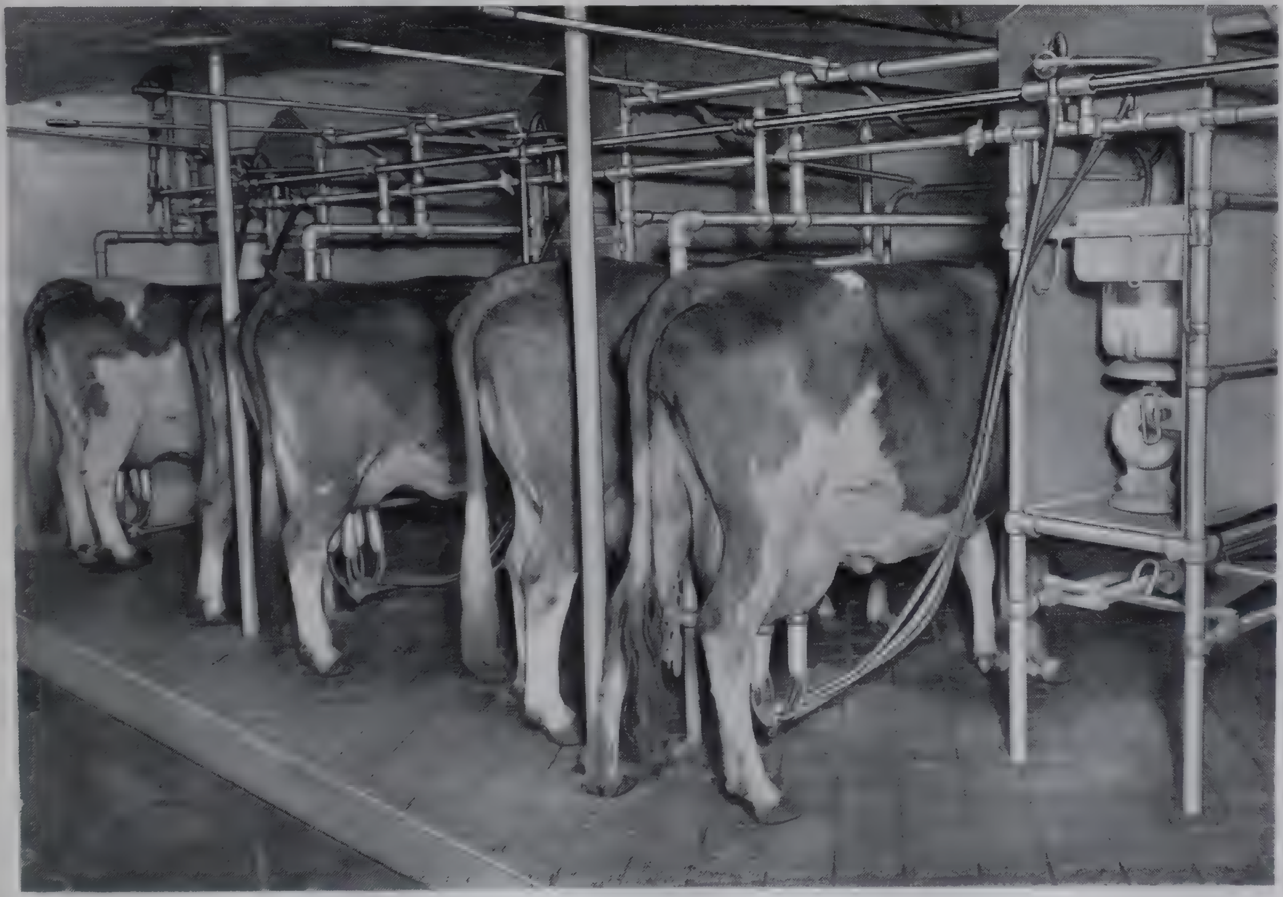
Many farmers are reluctant to install modern milking units owing to the very bad keeping quality of the milk produced by the older type of machine. This was due primarily to inefficient sterilisation, caused by badly designed plant which was difficult to cleanse. The modern milking machine is an altogether different proposition in which these faults have been eliminated.

Choice of Machine

Milking machines are of two types :

(1) *Individual delivery type,* in which the milk is collected in a receptacle placed by the side of the cow.

(2) *Collective delivery type,* where the milk is taken from the cow and delivered by means of a milk pipe-line to the dairy, where it is cooled and passed into churns.



By courtesy of Gascoignes (Reading) Ltd.

FIG. 86. Gascoigne 3-Point Auto-Recorder.

Machines of the individual delivery type are more popular, and are most often used for milking the animals in cowsheds. The motive power is supplied either by electricity or the common type of farm oil engine. In rural areas which are still without electric power, such power can be generated by a Diesel engine at a rate comparable to the price of current from the grid. The type of machine installed depends upon the individual requirements of the purchaser, but certain points should be noted, as follows :

(1) *Rubber piping should be reduced to a minimum.* The rubber used should be of good quality, capable of standing frequent steaming without deterioration. It should be mentioned that experiments appear to indicate that synthetic rubber is less absorbent of milk fat than is the natural article.

(2) *The teat-cup linings should be simple in construction and easily accessible for cleansing.*

(3) *Pails and other metal parts should be smooth and seamless,* with as few joints as possible.

(4) *The whole apparatus should permit of easy dismantling and reassembling.*

(5) *The vacuum line should be provided with an adequate slope* so that condensed moisture may be drained off, and suitable drainage taps should be provided at all essential points. (Condensed moisture in the tubes has a high bacterial content and, should it find a way into the milk, high bacterial counts will automatically follow. This has been a difficulty in the past, when producers' milk showed high counts.) Pipe lines should preferably be on a level with the cow and a cut-off device to prevent the milk of individual cows running back into the pipe line should be provided.

(6) *Maintenance of constant pressure is of the utmost importance.*

Different makes of machine show differences in the construction of the teat cups and milk pail, the rate of pulsation, and the method of control, while the method of assembling the parts also varies. Difficulties are apt to arise with the collective delivery type of milking machine in the cleansing and effective sterilisation of the pipe-line.

The principal types of milking machines on the market, together with certain of their outstanding features, are as follows :—

Alfa-Laval System

This is a very popular type. The milk is conveyed direct from cow to container under vacuum, and does not come into contact with the hands of the milker, the air, or any other source of contamination. With the aid of this apparatus it is claimed that one milker is able to handle three or four machine units and milk 30 to 40 cows per hour, recording the weight of milk from each animal.

Alfa-Laval Combine Recorder

This apparatus automatically conveys the milk from the cow to the churn or bottle, carrying out the several operations of feeding, milking, recording, equalising, straining and cooling the milk. It is an obvious choice when a large number of animals require to be milked.

Gascoigne Auto-Recorder

This is a combination of the " bail " method of milking with a highly efficient system of electrical self-recording. It is claimed that a herd of 50 to 60 cows may be managed and milked with only one man and a boy in attendance. The milking shed or cowshed in which the Auto-Recorder is installed is lighted by electricity, the cows are timed, and the milk is weighed, strained, cooled, and equalised automatically, being conveyed direct to the churns while the animals are automatically fed.

Gascoigne Milking Machine

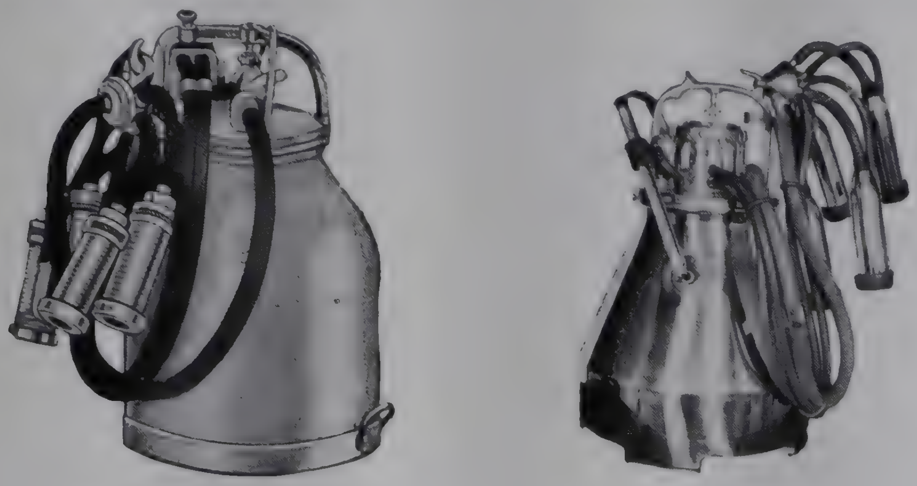
This apparatus is manufactured by Messrs. Gascoigne of Reading, and embodies the results of many years' trial and experience. Cleansing is simple, and an important feature is the teat cup which is so designed that the " squeeze " commences at the top and proceeds downwards, thus completely stripping out the teat.

Simplex Milker

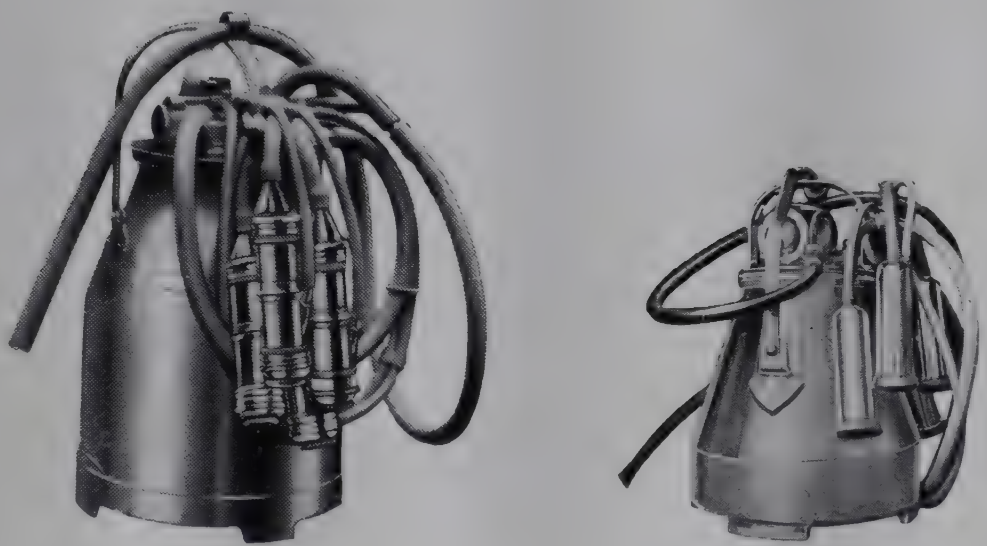
This milking machine which operates at very low pressure, combines lightness with simplicity. An automatic cut-off is provided so that it is impossible for bacteria-laden air to pass over the wet inner surface of the teat cup liners. In spite of the low vacuum employed (10 to 13 inches) the teat cups do not fall off nor are back cords required to keep them in position. One unit for every 10 to 12 cows is recommended.

Hosier Auto-Recorder

This machine is of the pipe-line type, the milk being drawn from the cow through an enclosed cooler and delivered to the churn under vacuum. The weight of the milk from each cow is automatically recorded as it passes into the pipe-line. The plant is cleansed by means of a high-pressure boiler.



(*a*) " Alfa-Laval." (*b*) " Gascoigne."



(*c*) " Manus." (*d*) " McCormick-Deering."

By courtesy of the makers and of The British Rubber Publicity Association.

FIG. 87. Types of Milking Units.

McCormick-Deering Milker

This machine displays a high standard of workmanship. It can be obtained in single units, driven by engine or electric power, with single- or double-cylinder vacuum pumps. The two-piece teat-cup assembly is a very neat piece of work. It consists of a one-piece heat-resisting rubber liner and a metal shell. The apparatus is easy to clean, and can easily be taken to pieces and reassembled.

Macford Milking Machine

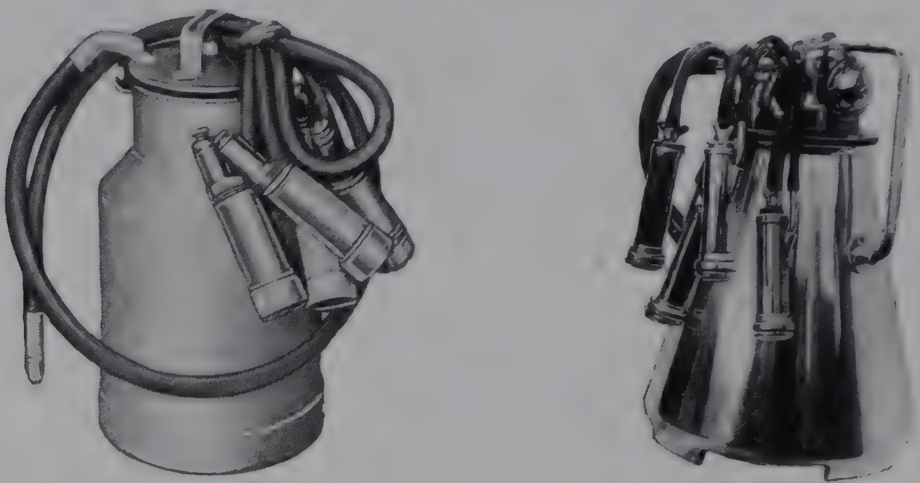
This is a bucket type apparatus, the bucket being constructed of stainless steel which is light but durable, while it is easily cleansed. A sight glass is provided below each cup which permits the operator to observe the milk flow. It is thus possible to see at a glance whether or not the cow has been milked out.

Manus Milking Machine

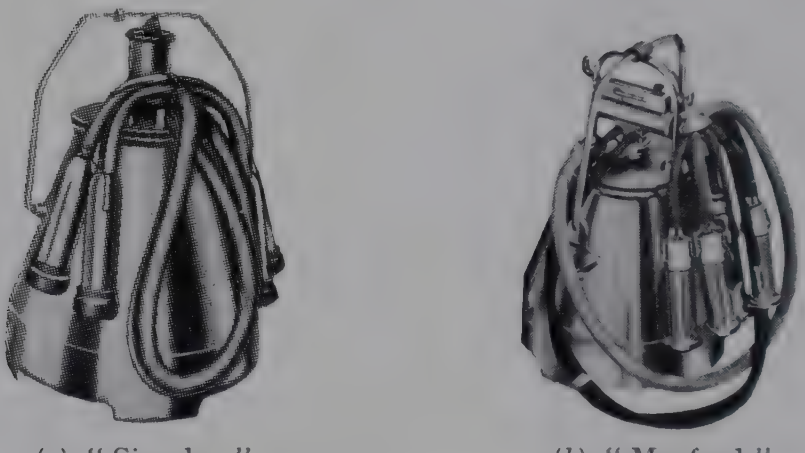
This is another useful type of machine. An important feature of this apparatus is the vacuum pump, which is so constructed that it may be connected to a special type of water elevator if desired. The teat cups are easily cleansed after taking apart and quickly reassembled.

Vaccar Machine

An apparatus of this type was first installed in 1907 and is still in use. This fact speaks well for the solid construction and high-grade material used in manufacturing what is a fast and clean milking machine. The teat cups can be supplied with tight or slack liners and the apparatus employs an air admission aperture in the mouthpiece of the cup to break down the vacuum applied at the upper end of the teat without disturbing the ordinary milking vacuum. The whole apparatus is a sound and workmanlike piece of mechanism.



(*e*) " Wallace." (*f*) " Vaccar."



(*g*) " Simplex." (*h*) " Macford."

By courtesy of the makers and of The British Rubber Publicity Association.

Fig. 88. Types of Milking Units.

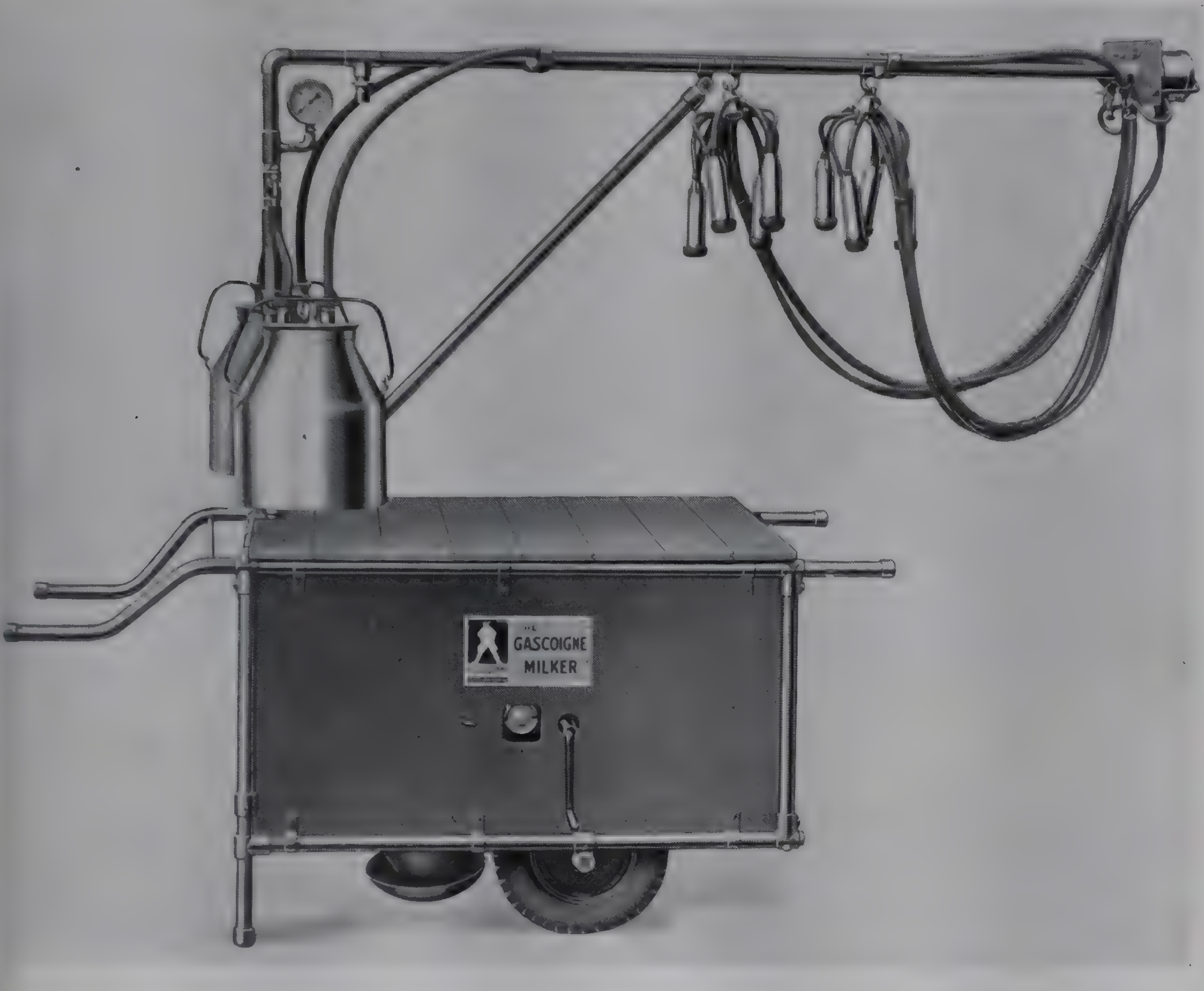
Wallace Milker

This is also a pipe-line machine. The teat cup consists of a rigid cylindrical outer casing constructed of aluminium, and a heavy flexible lining composed of a special rubber compound. Effective sealing between the lining and the outer casing is ensured. The length of the teat cup provided depends upon the breed to be milked, a longer teat cup being fitted for Ayrshire cows.

From the aforementioned types it is easily possible to choose one which will give satisfactory service.

Use of Milking Machines

The action of milking machines in general is simple. A vacuum, varying from 10 to 15 inches, is maintained in the pipe-line running through the cowshed (when such is part of the machine) and the pulsations are automatically controlled. The milking unit consists of a seamless, heavily-tinned or stainless-steel pail, which is fitted with a tight-fitting cover to which the four teat cups and pulsator are attached. The rate of pulsation varies with the different makes. On some, this rate can be adjusted to suit each cow. The teat cups are constructed with detachable rubber linings which are pliable and under tension. By the action of the pulsator these linings collapse over the teat from the upper end downwards, then open again to the normal shape. This action approximates as closely as possible to the action of the calf's mouth when sucking. The pressure should not be too high nor should the apparatus be left attached to the teats for over-lengthy periods or damage to the udder may ensue.

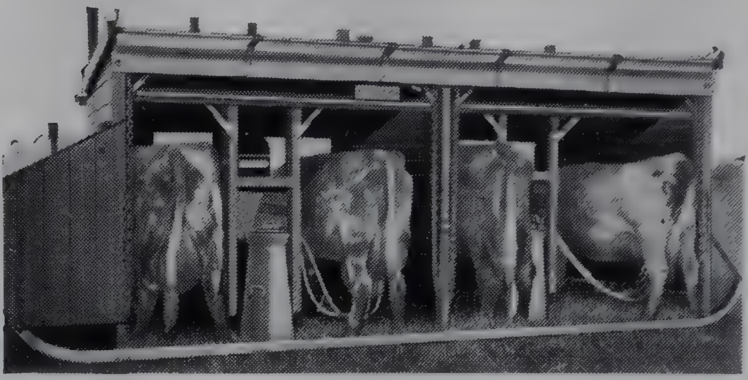


By courtesy of Gascoignes (Reading) Ltd.

FIG. 89. Gascoigne 10/20 Milker (Portable Bail).

The success or failure of machine milking depends largely upon the individual operating the machine and his attitude towards machine milking. Labour which cannot produce clean milk by hand will certainly not do so by the use of a machine. It is particularly essential that clean conditions should be maintained in the cowshed where a machine is used. All the necessary removal of bedding and feeding-stuffs should be accomplished some time before milking commences. As regards the actual animals, the precautions to be taken when machine milking is practised are quite as stringent as those necessary when the animals are hand milked. The udders, flanks, and hindquarters of the animals must be kept clipped, and the animals should be groomed and washed before milking takes place. It is important that the teats should be dried after washing, so that no water can accumulate on them and so be drawn into the milk during the process. All litter should be removed from the region of the cow's hindquarters. The fore-milk from each teat should be rejected immediately before the teat cups are applied. For a herd of 30 cows three milking units would be required with an extra bucket, additional units being required for larger herds. Before the actual milking operations commence it is necessary to ensure that each unit is in proper working order, that the tubes are attached and the lids fitting tightly, and that the plant as a whole is working smoothly. The drainage taps on the pipe-lines should be closed, the vacuum tube or tubes attached to the pipe-lines, the taps opened, and the teat cups affixed to each teat. The set of four cups is usually supported by strong cord fixed around the animal's body and secured by a clip, thus taking the weight of the assembly off the teats and the udder.

The time taken to milk each animal varies from four to eight minutes, although the cups can be left affixed to the teats for a longer period without ill-effect. The time taken varies according to the yield of the animal. A glass observation tube is generally provided, and when it is seen that little or no milk is passing into the bucket, the teat cups should be removed. The speedy removal of the cups accustoms the cow to yield its quantity of milk quickly. Slight massage of the udder assists in thoroughly emptying the milk cisterns. The cups should not be allowed to operate when the unit is being moved from one animal to another but should be turned off. A common practice is to turn back the tubes holding the cups in order to cut off the suction until they are fixed to the teats of the next animal. If this is not done, contamination of the milk from impurities in the air is probable. Some of the animals will "milk out" without any hand stripping, but it may be necessary to finish off each animal by hand to ensure that all strippings are withdrawn. In practice, it is always advisable that the udders be handled by the person in charge, so that any abnormalities may be noticed sufficiently early to prevent serious trouble later. Strippings should always be withdrawn into a covered pail.



By courtesy of the Alfa-Laval Company.

FIG. 90. Skid Bail.

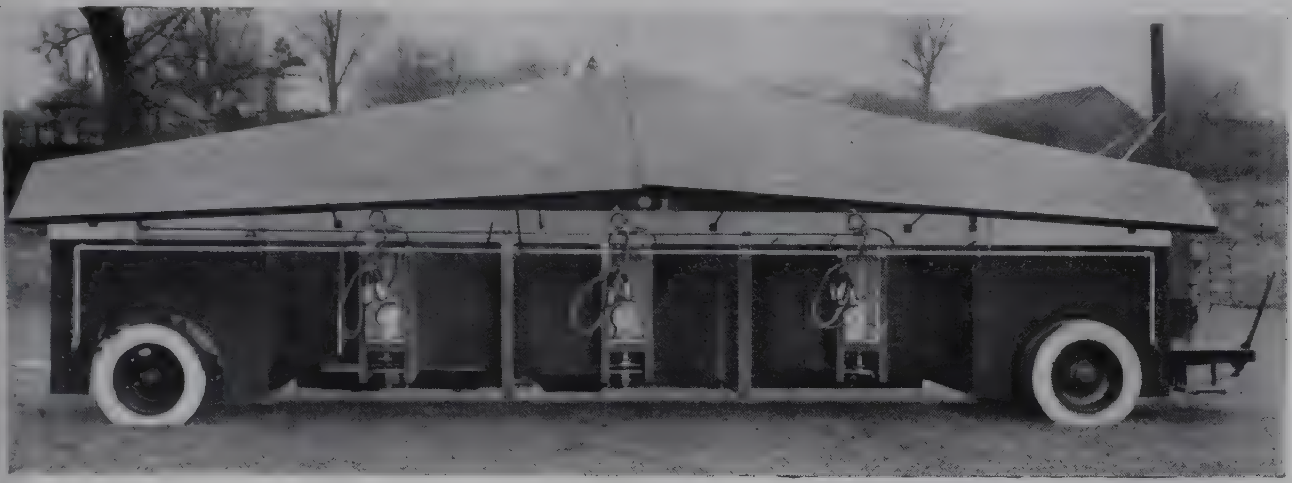
With newly-calved cows, the machine may be used as soon as the calf is taken away, while in cows in which the yield is declining, the machine should be used so long as this is worth while. "Hard" milkers can be more efficiently milked by the use of the machine, and also young cows with short teats and tight udders. The young cow takes to the machine much more readily than do cows which have been milked by hand for some years. Cows with three quarters only can be milked by cutting off one teat cup. This is done by bending back the rubber tube which attaches the cup to the bucket and fastening same with a rubber clip. The teat cup should never be left operating in such cases.

When milking operations have been completed, proper and efficient cleansing of the plant is necessary. This should preferably be carried out at least twice daily, but can be done once daily if time cannot be spared for dismantling the unit. If milk residues are allowed to remain in contact with the rubber surfaces, they are difficult to remove, so that, if the unit is not dismantled after each milking, it should be washed and sterilised in the assembled condition after cold water has been drawn through. Some producers do not dismantle the units more often than twice a week, but this practice cannot be recommended.

The process of washing and sterilisation should be carried out in the following stages:

(1) Clean cold water should be drawn through the teat cups into the bucket by attaching the unit to the vacuum pipe in the ordinary way. This should be repeated a few times with fresh clean water. Hot water at a temperature of 180° F. should then be drawn through in a similar manner.

(2) The units should next be dismantled, and all the teat-cup linings and rubber tubes brushed with the special brush provided by the makers for this purpose. The brushing should be carried out externally and internally, and the brush requires to be washed and sterilised after use. The washing and brushing should be thorough, as fat allowed to remain on rubber surfaces leads to their deterioration. All metal parts must be washed and cleansed thoroughly in the usual manner.



By courtesy of Gascoignes (Reading) Ltd.

FIG. 91. Gascoigne Open-air Milking Bail. (Elevation.)

(3) All the parts should again be rinsed in hot water and allowed to drain.

(4) The parts should finally be sterilised with steam for 15 minutes at 212° F. All the rubber parts should be placed in a muslin bag and suspended in the steam-chest so that they do not come into contact with any metal. This prevents deterioration of the rubber.

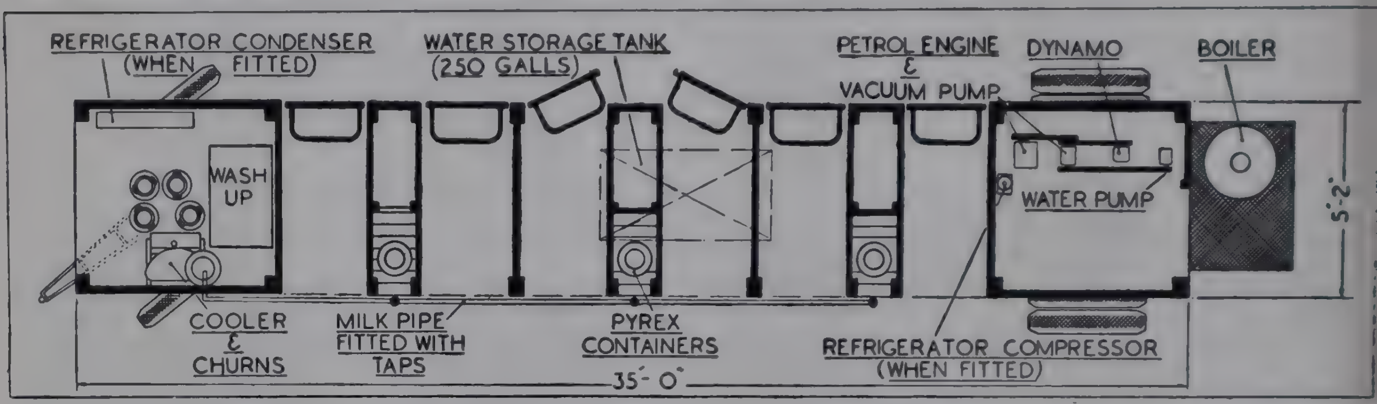
Sodium hypochlorite solutions can be used for sterilisation purposes in the manner described on pages 140 to 142.

Milking machines of a reliable type, properly installed, and operated and cleansed in a proper and efficient manner, yield results in every way as satisfactory as those obtained by good hand milking.

Milking Bails

The greater use of milking bails, either portable or otherwise, in connection with suitable lands, is worthy of consideration as an aid to clean milk production, particularly in those parts of the country where the cattle stay out of doors for the greater part of the year. On scattered lands with firm soils, the proper use of portable milking bails with adjacent sheds for the shelter of the animals during inclement weather provide the most economical method. By the proper use of bails is meant the temporary and systematic fencing off of sections of grazing lands for penning cows prior to milking. The use of concrete platforms in fields in conjunction with portable bails is often practised, but such a method cannot be recommended. Pounding of the ground by the animals and dirty conditions often result and one of the chief advantages of a portable bail, that of returning the manure to the land, is lost. As with milking machines, cleanliness is again extremely important.

Fig. 89 shows a portable milking machine which can usefully be employed for a small herd or where scattered buildings are employed. A larger type of portable bail which possesses the considerable advantages of handling the


REFRIGERATOR CONDENSER (WHEN FITTED)
WATER STORAGE TANK (250 GALLS)
PETROL ENGINE & VACUUM PUMP
DYNAMO
BOILER
WASH UP
WATER PUMP
5'-2"
COOLER & CHURNS
MILK PIPE FITTED WITH TAPS
PYREX CONTAINERS
REFRIGERATOR COMPRESSOR (WHEN FITTED)
35'-0"

By courtesy of Gascoignes (Reading) Ltd.

FIG. 92. Gascoigne Open-air Milking Bail. (Plan.)

milk from cow to churn, together with the sterilisation of the utensils, is shown in Figs. 91 and 92.

Removal of the Milk

Where the milk is collected from each animal in separate receptacles, it is essential that the product should reach the dairy in the shortest possible time. This speedy removal is essential in view of the many possibilities of contamination which will occur if milk is allowed to stand in the cowshed in open pails, as is so often the case. Milk may be removed to the dairy by hand or may be poured into a covered receiving pan situated at one end of the cowshed, after which it should flow through into the dairy to discharge over the cooler. If it is not possible or convenient to remove milk immediately, a receptacle large enough to hold the milk of four or five cows and provided with a tight-fitting cover is essential. Unnecessary pouring of milk in the cowshed should always be avoided. Milk readily absorbs any malodours or flavours which may be present in the vicinity, and the proximity of the product to material of such a nature should be avoided. Carrying pails should be of four gallons capacity, straight sided, constructed of stainless steel and possess a tight-fitting lid.

Straining

When the milk has left the cowshed, it is generally passed through a strainer before being cooled. The value of straining is a much-debated subject.

Many farmers are of the opinion that dirty milk may be rendered clean by the process of straining. This is fallacious, as no amount of straining will render dirty milk clean, since the great bulk of dirt which obtains entrance to the milk is soluble.

If the production methods of all cowkeepers were satisfactory, straining might well be abolished for the following reasons :

(1) Strainers under certain circumstances may add appreciable numbers of organisms to the milk. Improperly sterilised strainers, dirty straining cloths, and the use of cotton-wool discs for too long a period all add their quota of bacteria.

(2) The farmer who believes that the term " dirty milk " is used to denote milk containing visible dirt, and who does not understand that milk is more generally polluted by invisible organisms, will be lulled into a false sense of security by the use of strainers.

(3) If milk contains any disease-producing organisms, the strainer, which will probably retain some of these, will inoculate further batches of milk passing through.

The ideal state when strainers are no longer required has not yet been attained, as, even in the hands of the cleanest producers, small portions of dirt or loose hairs from the animals, whether in large or small quantities may occasionally obtain entrance to the milk. Although this quantity may not be sufficient to cause a high bacterial count if quickly removed, such milk requires straining, as the appearance of milk containing floating particles of dirt and straw would not assist a ready sale.

If any manure falls into milk, only about one-eighth can be removed by straining, the remaining seven-eighths being either originally liquid or dissolved later in the milk. Straining should therefore be practised rather as a precautionary measure than as a cure for unsatisfactory production methods. The producer's object should be to exclude all possible dirt and not to rely upon the strainer to remove it.

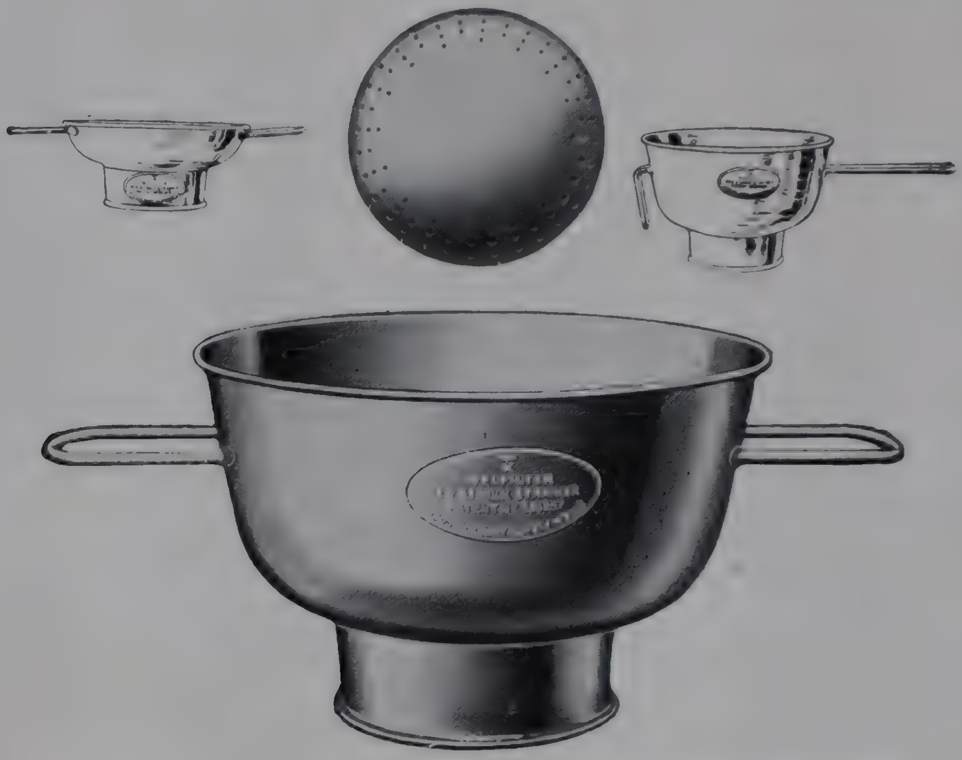
Having concluded that the precaution of straining is desirable prior to cooling milk, it is important to decide when this operation should be carried out. It may be stated categorically that the milk should be strained *as early as possible after milking.* If milk is poured into a receiving tank in the cowshed, it should pass through a covered strainer before entering the tank. In this connection the practice of fixing a large straining cloth over the receiving tank is to be condemned owing to the large size of cloth required, this being difficult to clean.

The producer has the choice of two types of strainer. These are :

(1) Those making use of a straining cloth.
(2) Those employing a cotton-wool disc.

The method of straining through a *cloth* cannot be considered so satisfactory as that which makes use of cotton-wool disc filters. If, however, such straining cloths are used, they should be of good quality. Two cloths should be provided, one for use with the morning's milk and one for use with the evening's milk, and they should be disposed of when they have been in use for about a week. The cloth used for evening milking should be soaked in water overnight, and this process should be repeated with the other cloth after the morning milking is over. After soaking, the cloths should be repeatedly rinsed in cold water to prevent them becoming foul, then washed in hot water and soda, rinsed in clean hot water, and finally boiled for some time to ensure thorough freedom from all milk adhering to them. After boiling, the cloth should be refixed in the strainer and steamed with the other utensils. After sterilisation, cloths and strainers should be stored in a clean place with the other utensils until required for further use.

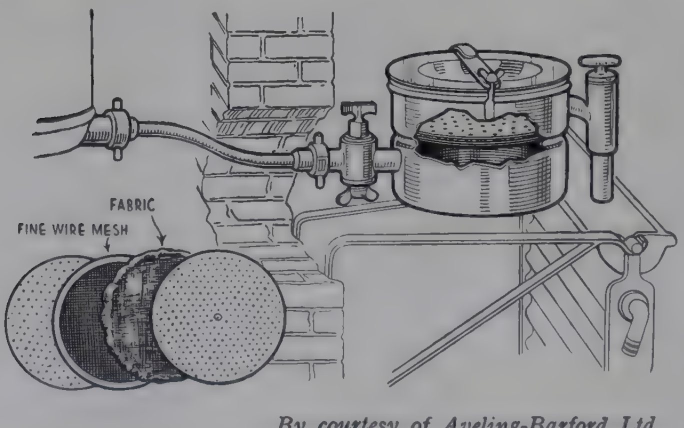
The best type of strainer is one which relies for its efficiency on the use of a *cotton-wool disc*. In this type of strainer, a fine, thick, circular cotton-wool disc is held in position between two perforated tinned-copper discs by means of a spring. In some patterns a strong wire gauze is used instead of the lower disc. The strainer should always be so designed that milk falls on to a metal plate first, instead of falling directly on to the straining material.



By courtesy of Clare's Service.

FIG. 93. "Welfilter" Strainer.

The metal plate bears the direct weight of the falling milk, and there is thus little chance of any particles of dirt being forced through the strainer or of the formation of perforations in the cotton-wool filter medium by the weight of milk. Good-quality discs should always be provided and, as they ought to be used on one occasion only, it is impossible for them to contaminate further supplies of milk as the result of inefficient sterilisation. The discs are sometimes retained between perforated gauzes, but these do not permit of easy cleaning as compared with the perforated tinned-copper discs, and are therefore not to be recommended. The strainer, complete with the new disc, should always be assembled ready for use and then steamed with the other utensils. Fig. 93 shows an efficient strainer which possesses no wire gauze disc likely to become contaminated.



By courtesy of Aveling-Barford Ltd.

FIG. 94. Pipe-line Filter (Section).

A satisfactory type of strainer is the *pipe-line filter* manufactured by Messrs. Aveling-Barford Ltd. Filtration with this type of apparatus takes place in an upward direction against gravity, and perforation of the filtering media does not occur. This method is for use in the pipe-line between the receiving pan and the cooler. (For further details see page 207.)

Cooling

The keeping properties of milk depend upon the number of bacteria contained. Bacteria multiply more rapidly at high temperatures than at low, and the higher the temperature the more rapidly do they increase, this being especially the case with those organisms which cause rapid souring and objectionable flavours in milk.

Many producers, especially those who retail their own milk direct to the consumer, are very reluctant to cool their product, owing to the objections which are raised to cooled milk by many of their customers. The Milk and Dairies Order, 1926, allows far too much latitude in this direction, and it would have been much more satisfactory if provision had been made for the compulsory cooling of all milk immediately after production, irrespective of when or how it was afterwards distributed. In this connection, consumers require to be educated in order to make it clear that cooled milk does not imply a stale product.

It should be pointed out also, that producers sign a contract with the Milk Marketing Board in which they agree to cool *all* their milk to 60° F. or thereabouts, but this stipulation is more honoured by its breach than its observance This state of affairs cannot be unknown to the Board who apparently take no action to enforce this part of their contract, possibly because the impracticability of being able to do so in every case, is recognised.

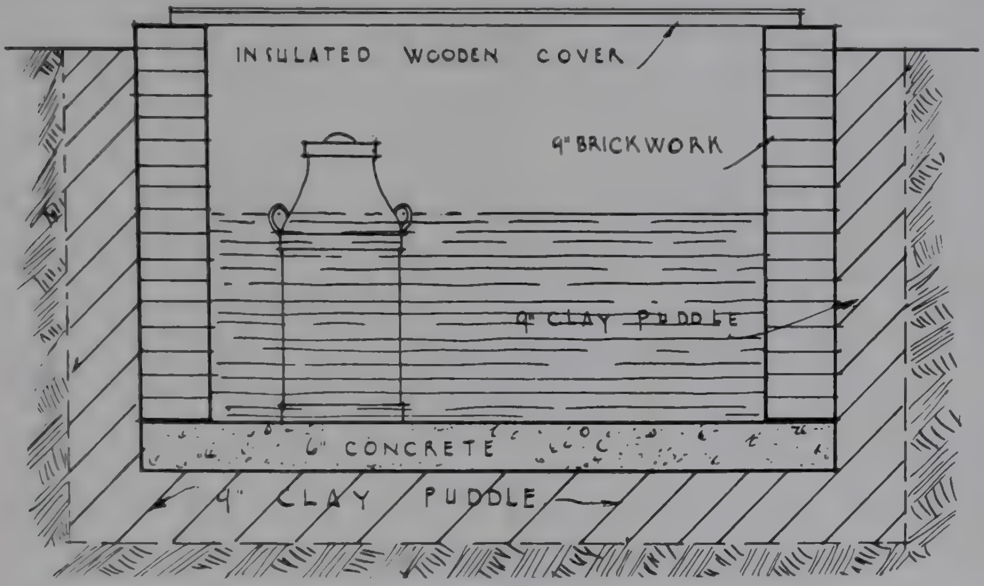


FIG. 95.

Whether or not milk is sold by the producer direct to the consumer, it should always be cooled, and the process carried out immediately after straining has taken place. Cooling should be looked upon as one of the most important aids to clean milk production and distribution. Although an improperly used and inefficiently sterilised cooler may increase rather than retard the bacterial content of milk, there can be no doubt that effective cooling greatly decreases the loss of milk through souring and prevents the rapid multiplication of any bacteria which may be present in the product. It is a happy fact that many more coolers are being provided on farms, and that the prejudice both of the producer and the consumer against the cooling of milk is being steadily and surely overcome.

The bacteria most commonly found in milk grow more rapidly at temperatures above 60° F. At temperatures above 70° F., milk speedily sours. If the liquid contains as few as 10,000 bacteria and is held at 60° F., it will become sour in fifty-three hours. If the same milk is held at 50° F., it will not sour for eighty-six hours. Every effort should therefore be made to ensure that the milk is cooled to a temperature as low as is possible under the prevailing circumstances. It is to be regretted that there are those who, through the lack of a satisfactory water supply, will be unable to cool milk as it should be done. If a producer in such a position can deliver his milk to premises where it may be cooled within a very short period after milking, this omission is not so serious, but the necessity for keeping milk as cool as possible until it reaches the distributor must always receive attention.

It is possible for any farmer who has to store his milk for any length of time before despatch to the distributor to provide a suitable storage place in which the temperature of the milk may be slightly lowered and bacterial multiplication thereby reduced. Fig. 95 shows a section through such a storage cavity.

A cavity, roughly 6 feet by 2 feet by 4 feet deep, should be dug in a position obtaining a minimum of sun. The north side of the dairy would provide an admirable site for this purpose. The base, which is constructed of 6 inches of cement concrete, should be laid on 9 inches of puddle clay. The sides should be built up of 9-inch brickwork jointed with cement mortar, and this brickwork should be surrounded with 9 inches of clay puddle to render the whole perfectly watertight. A movable cover of wood, insulated for preference, should be provided, and the cavity filled with water to the required depth. A large number of churns may be immersed in the water up to the shoulders or handles when, if the insulated lid is placed over the opening, the milk will keep reasonably cool. Experiments have shown that the water in the tank, when constructed in this manner, will remain below the temperature of the air above ground. Table 12 below (Mattick) sets out the temperature records of water in a tank of this description taken during the months of June, July, August, and September.

TABLE 12.

Date.	Temperature of Water in the Tank. °F.		Atmospheric Temperature. ° F.	
	Max.	Min.	Max.	Min.
June 24th	55	55	68	54
June 27th	54	54	65	46
June 29th	54	54	72	50
July 2nd	58	56	76	54
July 13th	58	58	80	63
July 14th	59	58	80	59
July 15th	59	58	83	62
Aug. 26th	59	52	77	50
Aug. 27th	58	56	68	47
Aug. 31st	59	58	80	61
Sept. 10th	59	53	72	56
Sept. 19th	60	58	83	55
Sept. 25th	58	58	68	43

This method of water immersion will definitely prevent the temperature of cooled or uncooled milk from rising, but it must not be taken to be a satisfactory method of cooling milk. It is better, however, to maintain the temperature of milk below 60° F. by this method than to risk summer heat causing a rise in temperature, with a resultant increase in the number of bacteria present and a consequent loss of keeping quality. Water immersion in the cavity specified is not actually a method of cooling milk, being merely a means of preventing any rise in temperature with a consequent large increase in the bacterial content.

Milk in bulk cools slowly. Savage warmed 1 gallon of milk to 33° C. and poured the heated product into a cool 2-gallon churn. The rate of cooling is shown in the table below.

TABLE 13.

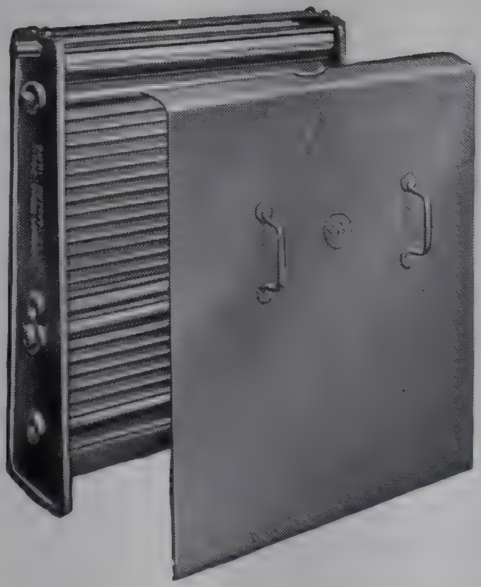
Time.	Temperature of Atmosphere. ° C.	Temperature of Milk. ° C.
11 am.	16	33
12 noon	16	30
1 p.m.	16·8	27·5
2 p.m.	19	26
3 p.m.	19	24
4 p.m.	19·7	24
5 p.m.	21	23

The rate of cooling of larger quantities of milk would be considerably slower.

The speed at which cooling is accomplished depends upon certain constant factors which are :

(1) The temperature of the milk before cooling commences.
(2) The temperature of the water used for cooling.
(3) The extent of milk surface exposed to the cooling surface.
(4) The speed at which the milk passes over the cooler.

With an ample supply of water and sufficient time, by careful regulation of the flow of liquid over the cooler it is possible to cool milk to within two degrees of the temperature of the water used for cooling, but unfortunately this Utopian state of affairs is rarely attained in practice. Thus, if the water is at a temperature of 55° F., the milk should be capable of being cooled to within 57° F. To attain this degree of cooling it is necessary to use one of the many types of *milk cooler* now upon the market. An adequate water supply is also essential for satisfactory cooling, but few public water supplies are cool enough to give really satisfactory results. In such instances the practice is a pretence and a wastage of time and water and for a production of over 50 gallons of milk per day, water cooling is unsatisfactory. Many farmers who obtain their water supply from deep wells make a serious mistake when using such a supply for cooling purposes. Deep well water is usually of low temperature but, to supply the cooler, the water is pumped from the well into a storage tank. If too much water is pumped into the tank at one time it



By courtesy of the Dairy Outfit Co., Ltd.

FIG. 96. Flat Cooler with Cover Removed.

quickly reaches atmospheric temperature, with a consequent loss of cooling power. Care should be taken to ensure that water is pumped only as required, so that it may pass fairly rapidly through the tank to the cooler.

There are two types of cooler in general use, as follows:

(1) The flat type—most often used.

(2) The cylindrical type—not so common as the previous type, and generally used for cream cooling.

The choice of cooler is important, as it has a very important influence upon the bacterial content of the milk. The essentials of a good cooler are:

(1) The apparatus should be of robust construction, heavily tinned, and well finished.

(2) The cooler should be capable of cooling the milk to a temperature of within 2° or 3° F. of the water, when properly used. Ample cooling surface is extremely important. The largest cooling surface possible should be provided for quick cooling to low temperature irrespective of the quantity of milk to be so treated.

(3) The apparatus must permit of easy cleansing.

(4) The cooler must be suspended in such a manner and its water joints must be so arranged that it can be easily removed for sterilisation.

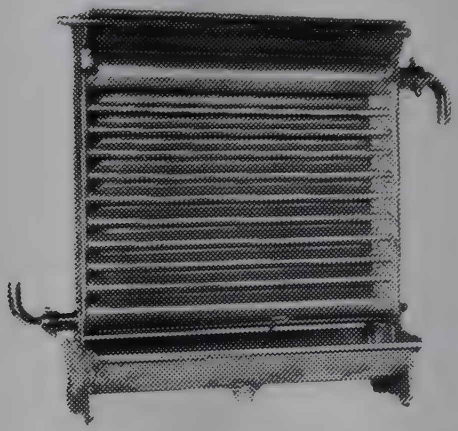
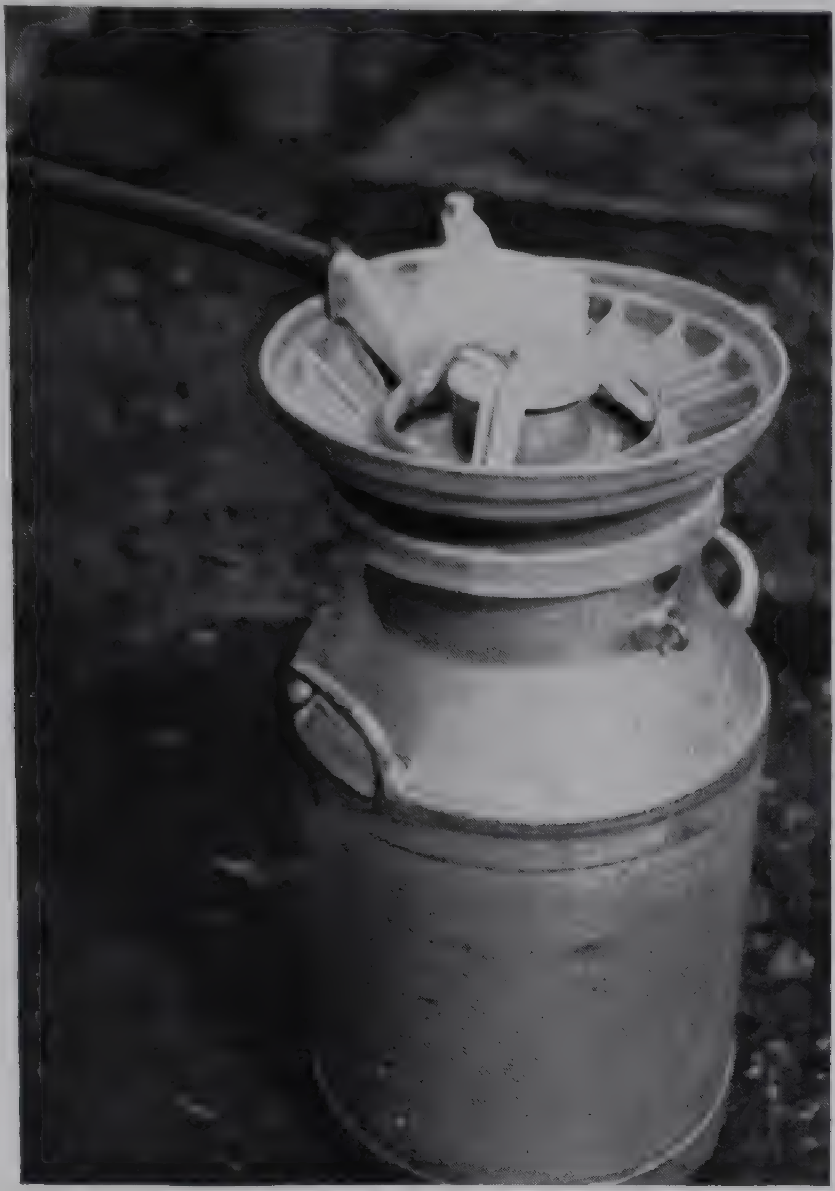

By courtesy of Clare's Service.

FIG. 97. "Wessex" Milk Cooler.

A cooler with wide corrugations and constructed without end-pieces, which often render the cleansing of the utensil difficult is extremley desirable. The upper and lower troughs should be easily removable. Coolers may be suspended from brackets attached to the wall (see Fig. 57) or, as shown in Fig. 101 on page 183, fixed on a separate stand. The latter method is to be preferred.

A novel form of milk cooler, known as the "Turnus" Cooler and Aerator, shown in Fig. 98, can now be obtained, which is designed to fit into the necks of the churns of normal capacities. The apparatus takes the form of a circular rotor to which are attached two stainless steel blades or agitators. When placed on the churn the outside casing of the rotor acts as a lid, the blades projecting down into the centre of the milk. The inner part of the rotor is connected to the water supply and this revolves slowly, causing the agitator blades to turn and gently circulate the milk against the chilled walls of the churn. The waste water is distributed over the outside of the churn to act as the cooling agent. By its use it is possible to cool a 10-gallon churn of milk from 95° F. to 52° F. in 21 minutes (with water at 50° F.). Each machine can cool six churns of milk at each milking.

The coolers in common use consist of tinned-copper tubes through which water circulates, the water entering the tubes at the base of the apparatus and leaving at the upper end. The warm milk runs over the tubes from the top and empties at the bottom into a churn or other receptacle fixed under the outlet. Approximately 6 gallons of water are required for each gallon of milk to be cooled. Since the milk passes over the surface of the cooler, it should be fixed in a clean situation, i.e. the milk room of the dairy, and should be suspended out of any draughts which might blow dust into the milk. Detachable metal covers which protect each side of the cooler from contamination can now be obtained at a small extra charge. The water used for cooling purposes should be perfectly pure, as occasionally a leak may occur and the cooling water may gain access to the milk. As a means of preventing such an occurrence it is advisable to examine the cooler carefully for any leakage whenever it is used, and for this purpose water may be allowed to run through when no milk is passing. Water should never be left in the cooler as, if this is done, the life of the apparatus will be seriously shortened and serious damage may be caused during periods of frost. If ice can be obtained, the temperature of the cooling water may be considerably lowered with beneficial results by means of the device shown in Fig. 99.



By courtesy of Hiron and Rempler Ltd.

FIG. 98. "Turnus" Milk Cooler.

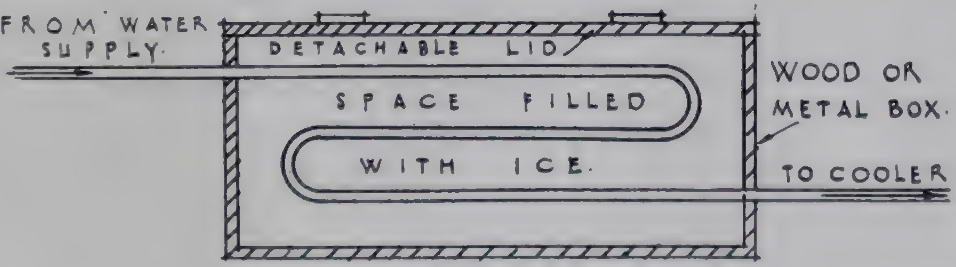
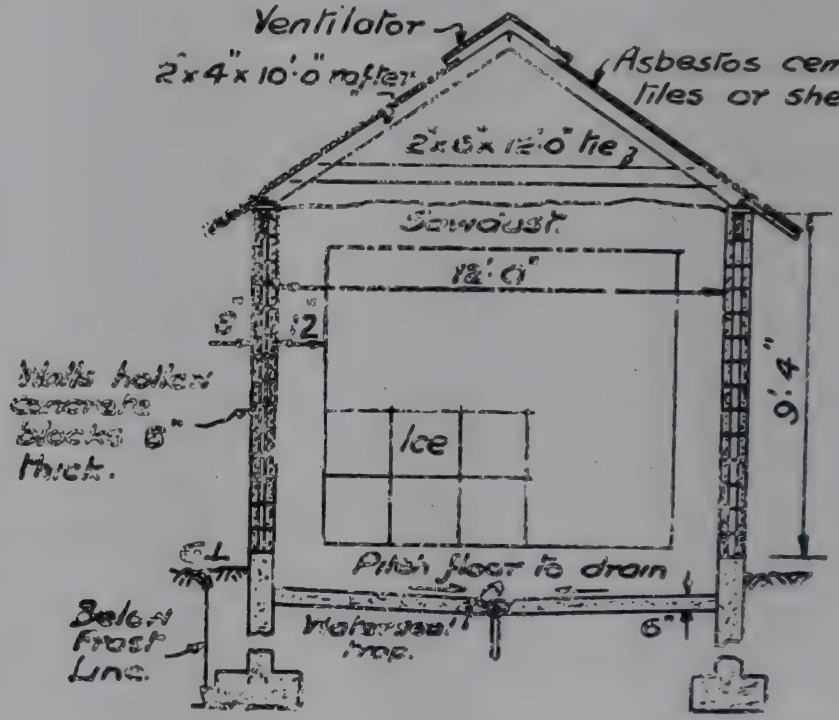


FIG. 99.

Coolers must be washed and sterilised directly after use, and should be protected from contamination until required again. Although coolers are intended as a means of restricting or retarding the growth of any bacteria, they are often a source of contamination if not properly cared for, by reason of their design and construction. Particular attention should be paid to any tap or plug with which the cooler is provided, to ensure that such are sufficiently cleansed. As it is essential to have as large an area of cooling surface as possible in contact with the milk, coolers are constituted with a series of corrugations. These are essential but render cleansing difficult, this difficulty being often increased owing to the small space between the corrugations. The corrugations should be sufficiently wide apart to allow of the fingers reaching every part of their surface. As a result of wide corrugations the cooler may be increased in size, but this should not be regarded as a disadvantage.

The cooler should be immediately re-tinned as soon as the copper begins to show through the tinned surface. If this is not done, the small exposed area of copper may taint the milk, following chemical action.

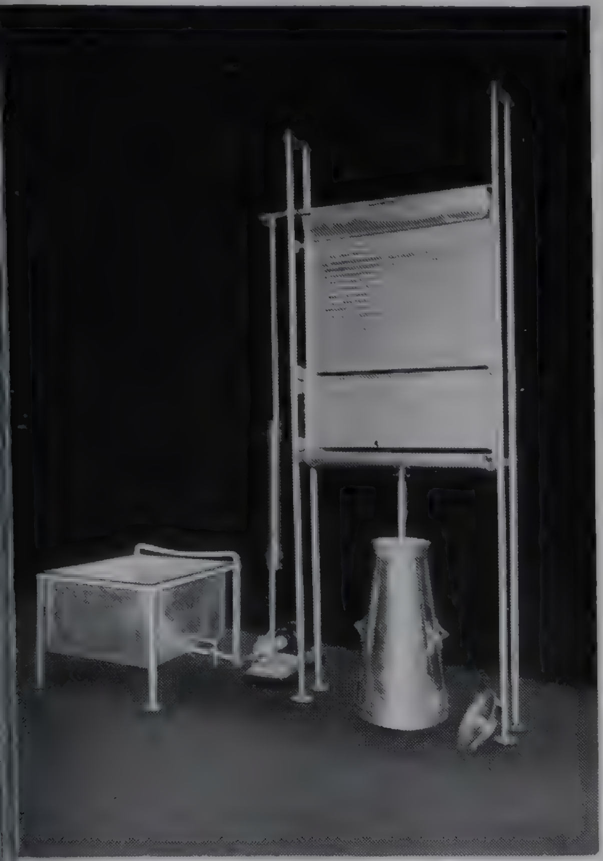


By courtesy of the Cement and Concrete Association.

FIG. 100. Ice House.

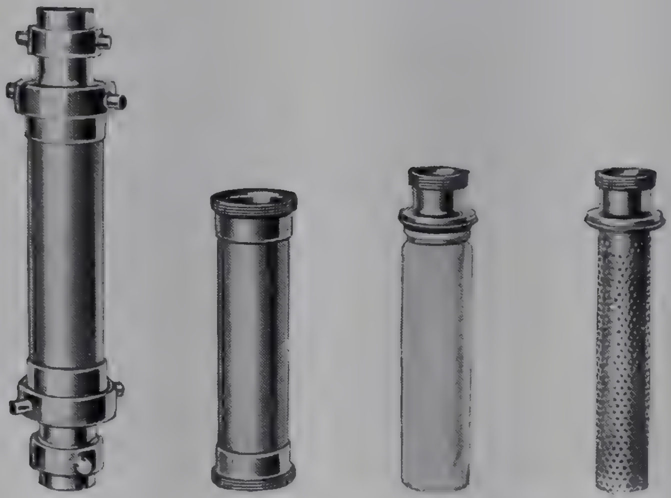
Ice-houses, to assist in cooling milk, have not been adopted in this country although, by their employment, it would be possible to obtain ice even during the summer months. Ice is collected during winter and is placed in the ice-house until required for use. A rectangular excavation is made in the ground and the earth removed is formed into a bank which is thatched over. The ice is placed in the bottom of the cavity which remains at a low temperature, cold air being heavier than warm air. Ice could often be collected in the cold winter days by the expenditure of a little labour and if stored in such an erection, could be used for milk cooling in summer. The quantity to be stored is based on the size of the herd. One to one and a half tons per cow is usually allowed and one ton of ice would require from 40 to 50 cubic feet of storage space. The ice should be insulated from all surfaces by a 12-inch layer of sawdust. Fig. 100 shows a section through a typical ice-house.

Artificial cooling, although not in general use at present is becoming more popular and there are several excellent plants which may be used for this purpose. The use of artificial cooling is extremely desirable, and all producers and distributors should consider the question of installing one of these plants, and, if possible, providing a cold room in addition for the storage of the cooled milk in churns or in bottles. As previously mentioned, adequate cooling of milk by the employment of mains water is rendered difficult on account of the high temperature of such water during the warmer months of the year ; in many instances, it is impossible to reduce the milk temperature below 60° F. Cooling by mains water at premises where over 50 gallons of milk per day are produced is quite unsatisfactory. The ideal temperature to which milk should be cooled is 40° F., and this can only be attained by first cooling with water and then supplying a final cooling with either chilled water, brine or other refrigerant. There are innumerable makes from which to choose, but two of the principal types are mentioned below.



By courtesy of the Creamery Package Co., Ltd.

IG. 101. C.P. Fresh Milk Cooling Plant, with Milk Pump.



By courtesy of The Creamery Package Co. Ltd.

FIG. 102. C.P. In-the-Line Filter showing Components.

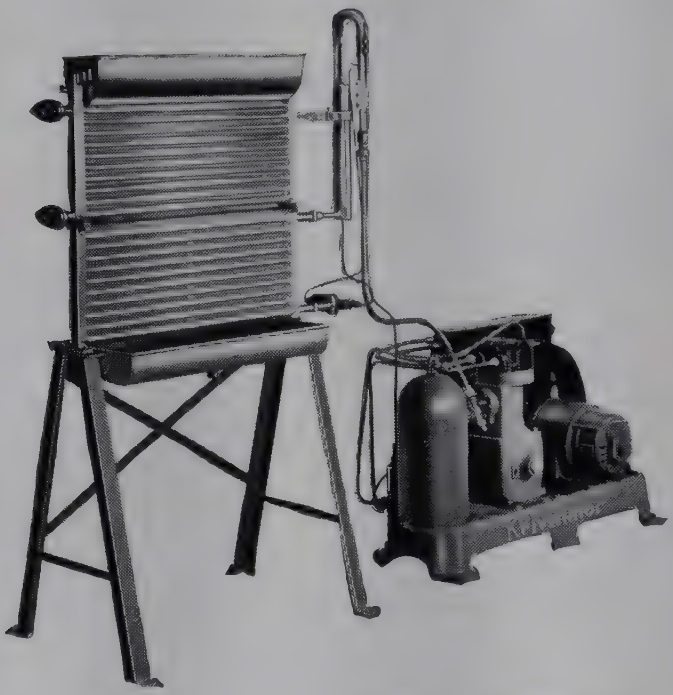
(1) *C.P. Fresh Milk Cooling Plant.* This plant, manufactured by the Creamery Package Company, consists of a milk tank situated near floor-level and a milk pump which forces the milk through a pipe-line filter to discharge over the cooler. The cooler itself is divided into two sections, the upper portion cooling by water and the lower section supplying a secondary cooling by means of chilled water or brine. The cooling is rapid and even, and the milk is aerated during the process to remove any gases which might produce " off flavours." The receiving tank is constructed of tinned steel, with all angles floated to provide easy cleaning. The milk filter consists of three principal parts, inlet fitting, body or barrel, and filter as illustrated in Fig. 102. The cooler is of the tubular-surface type, heavily tinned, and may either be fixed on a stand as shown or secured by wall brackets.

(2) *Kelvinator Coolers.* Fig. 103, shows a large surface-area cooler working by direct expansion of the refrigerant, with water in the upper portion. It will cool 45 gallons of milk per hour to a temperature of 45° F. Automatic safeguarding features are incorporated.

The Kelvinator Company also manufacture an interesting plant which does not require the use of water, an asset to those producers who are in difficulty as regards water supply, while they are experimenting with the production of an individual farm unit which employs a direct expansion coil to cool water in a trough in which churns of milk can be immersed.

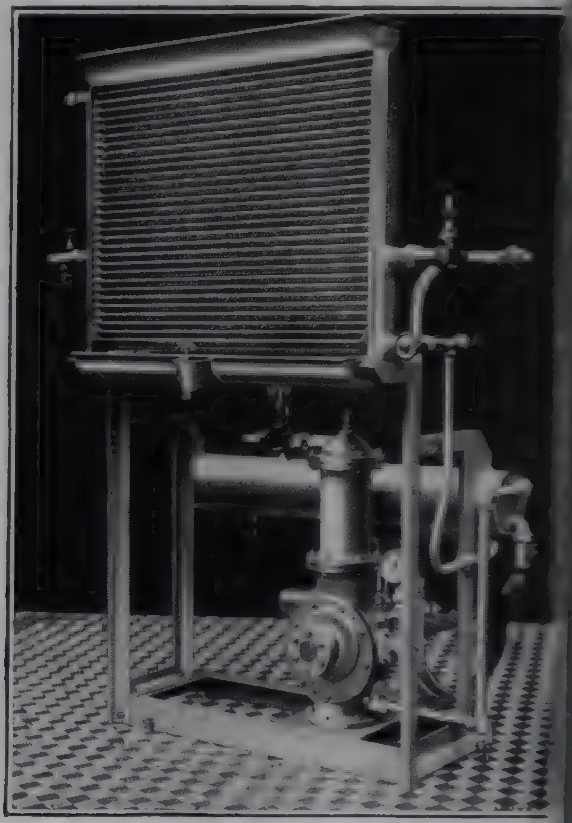
(3) "*Ethylor*" *Milk Cooling Plant.* This apparatus gives immediate refrigeration with absolute simplicity, works at low pressure and uses ethyl chloride, a non-poisonous refrigerant.

A *milk equaliser* is sometimes used in conjunction with the cooler. This ensures a milk of uniform quality, and by its aid it is possible to fill three or more churns simultaneously. The spouts are fitted with separate plugs, so that each can be used independently of the other.



By courtesy of Kelvinator Ltd.

FIG. 103. Kelvinator Direct Expansion Milk Cooler.



By courtesy of Clare's Service.

FIG. 104. "Ethylor" Milk Cooling Plant.

Every producer carrying out cooling operations of any kind should provide himself with an efficient *thermometer*, so that he may check the temperature to which the milk is cooled and thereby satisfy himself as to the efficiency of his operations..

Milk Churns

A very large number of producers throughout the country despatch their milk to distributors or to collecting stations either by road or rail, and make use of churns in so doing. In many industrial areas milk is either delivered in separate small cans to each consumer, such cans being filled when on the round from a churn ; or the customer's jug is filled by means of a measure from a 2- or 3-gallon hand can. Although this practice is to be deplored owing to the contamination which may ensue, it still continues. It will be seen, therefore, that the churn as a means of transporting and distributing milk is still an important factor and, this being so, it is important to consider the type of churn which is most desirable from the point of view of clean milk production and distribution. The original type with a wide base and narrow brim, known as the "railway churn," generally constructed with a capacity of 17 gallons is being rapidly superseded. This capacity possesses certain advantages, but there are also several disadvantages. It holds a considerable quantity of milk, and can be fairly easily handled by rolling. It is, however, difficult to cleanse properly owing to its depth, while the time taken in sterilisation is much longer than is necessary for smaller churns. It is also uneconomical when transport is considered and allows the rim over which the milk is poured to be contaminated by dust and also by the hands of those who handle it, which in many cases are none too clean. A further disadvantage is that a churn of this type weighs 2¼ cwt. when full and is difficult to lift to lorry height from ground level.

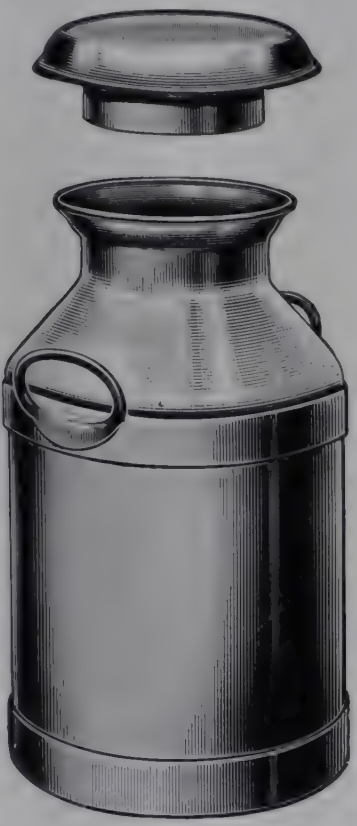


FIG. 105.

By courtesy of the Dairy Outfit Co., Ltd.

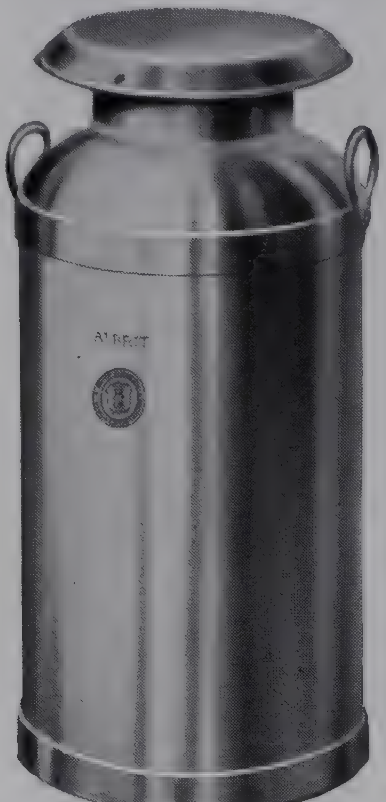


FIG. 106.

By courtesy of the Dairy Outfit Co., Ltd.

The ideal churn is one with a capacity of 10 or 12 gallons. Such a container is easy to clean and to carry, and can be quickly washed and sterilised in an efficient manner. Probably its highest recommendation from the standpoint of transport is that, with this type of churn, more milk can be carried in the same space as that required by 17-gallon churns. Thus, 90 gallons of milk in 10-gallon churns can be conveyed in the same floor space as 68 gallons in 17-gallon churns. Many producers held, and some still hold, to the belief that churns should be ventilated as a means of preserving the milk. It has been proved by experiment that such is not the case. The idea probably arose through the fact that, when milk sours in closed churn, the odour is more intense than when the churn is ventilated, owing no doubt to the concentration of gases emitted in souring. Ventilation apertures in the lid allow rainwater to enter, while dust is drawn into the churn by the movement of the milk. A *lid* which prevents milk splashing and is designed to throw off rain-water must therefore be selected. The choice of a suitable lid is definitely important.

Suitable types of churn are illustrated in Figs. 105 and 106, these being splash-proof, dust-proof, and rain-proof and constructed in various sizes. They have, also, no soldered joints or crevices.

Insulated churns have been introduced, and are useful to those who send their milk long distances during warm weather. This type of churn is made of steel and is seamless. It is also provided with an air-tight, spill-proof, and dust- and water-proof lid, being constructed on the principle of a thermos flask. The space between the inner and outer vessels is packed with a special insulating material and the air extracted, the churn maintaining its contents at the desired low temperature for many hours. Provision should be made to allow of the lid being locked and sealed in order to prevent any unauthorised tampering with the contents.

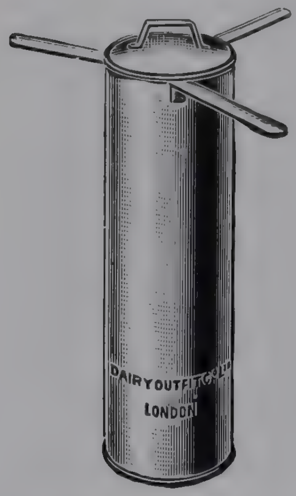


FIG. 107. Temperature Can for Churns.

The question of loss of milk through spilling is important, as it has been estimated that as much as 1 pint of milk may be lost from a churn on a journey of 30 miles by this means. There are *churn discs* to be obtained which are designed to prevent any spilling of the contents of the churn, although, with modern types of container, such are not required. Various sizes of disc can be obtained, these fitting into the collar of the churn and being secured by the lid. The principle is similar to that of the disc used to seal milk sold in bottles and, with the older types of churn, such discs should always be used.

The choice of churn is important. The interior of the vessel should be inspected on purchase to ensure that all seams and angles when present are so constructed that a thorough washing and cleansing is possible. Preference should always be given to those constructed in one piece, while the handles, if not collapsible, should be fixed vertically to provide economy of space in transit. It is also preferable that the gallon marks which are so often found placed on a brass strip fixed inside the churn should be engraved or indented in the metal of the receptacle itself. The brass strip has a tendency to work loose and so allow the milk to lodge behind it, which renders the proper cleansing of the churn difficult if not impossible.

Every churn should be washed and sterilised before being returned to the farm, as an improperly sterilised receptacle becomes a fertile source of contamination. This suggestion does not, however, relieve the producer from cleansing those churns which require it. Many farmers stress the point that churns received by them from collecting stations are improperly cleansed, but often appear to be indifferent to this state of affairs. If a farmer spends time and energy in producing a clean article, he should never insult his product by placing it in a dirty churn, but should cleanse and sterilise the offending utensil before it is used.

In cases where milk has been cooled and has to stand for some time before being placed on rail, the churns should be closed immediately after they have been filled. If no refrigerating chamber is provided and ice is available, a *temperature can* filled with ice may be used. Such a can is illustrated in

Fig. 107, this being suspended in the milk within the churn. The greatest care is necessary to ensure that the can is properly sterilised and maintained in a cleanly condition.

In warm weather, all churns during transit from the farm either to the distributor's premises or collecting station should be covered with light-coloured *covers*. These afford shade from the direct heat of the sun. Quite often churns may be observed awaiting collection on roadside stages or stands in the full glare of the sun. These stands require consideration. Many are ramshackle affairs which are an eyesore to the countryside. Some thought requires to be expended in their design and construction ; they should be provided with a roof and ought to be erected within the farm premises in order to prevent any infringement of Town Planning Regulations.

Financial Aspect of Clean Milk Production

The greatest drawback in the past to cleanliness in the production of milk has been the difficulty if not impossibility of obtaining a higher price generally for a cleaner and better-keeping product. Losses through souring have not been recognised as being caused by want of cleanliness, nor has the fact been appreciated that such losses can be greatly diminished if not entirely prevented by more attention to methods of production and cleanliness of utensils. The loss to each farmer cannot be estimated, neither can the extra time and labour required to bring about an improvement be calculated. An additional loss is likely to be incurred by the careless producer when price differentiation under the National Milk Testing Scheme operates, while even at the present time, dirty milk is likely to be returned with consequent loss of income. In many cases, however, no extra time is required, while the proper use of existing labour is very often all that is necessary. Another point in favour of hygienic conditions of milk production is the fact that animals kept under satisfactory conditions are healthier and capable of making more productive use of their food under such conditions. The maxim so frequently quoted, " Where there's dirt, there's danger," applies equally to the cowshed as to the home, since dirt in the cowshed brings in its wake disease and financial loss.

A further inducement to clean milk production is the extra bonus granted to producers of tuberculin-tested and accredited milks, while owners of attested herds qualify for a bonus for milk produced from such animals. Further details are given in Chapters VIII and XII of this volume, but it should be mentioned here that once a person is enrolled as an Accredited Producer, he is able to obtain a penny-farthing per gallon more for his milk, producers of other designated milks being rewarded *pro rata*. Financial rewards for the production of clean milk are thus obtainable, but it is still an open question as to whether these awards are sufficient when consideration is given to the food value of the product.

A producer who is careful in his methods and is capable of producing milk with low bacterial counts should seriously consider the question of marketing one of the various grades of Designated Milks for which a higher price is obtainable, and for which there will be a ready sale when the public becomes more milk-conscious.

Educational Measures

It can be categorically stated that there is still a great need for the better education of the producer, the distributor, and the consumer.

Much has already been done, and is still being done to educate the farmer and the dairyman to a realisation of their responsibilities as producers and distributors of one of the most important of the nation's food-stuffs. Assistance can be given in a variety of ways, as follows :

(1) Clean Milk Competitions. These are at present in abeyance but the cessation of hostilities will no doubt bring about their re-appearance as useful educative measures.

(2) Advisory Services by Agricultural Colleges and County Council Agriculture Organisers. These services are now part of the National Milk Testing Scheme.

(3) Courses in the handling and distribution of clean milk for producers, distributors and their employees together with demonstrations. Such courses are extremely important and most urgently required.

(4) Advisory services provided by Local Authorities. Every public health official should be capable of giving advice to either producer or distributor, if required.

Clean Milk Competitions which had, up to the commencement of the war, been in operation since 1919 have caused an increased interest in clean milk production, while they have had a markedly beneficial effect upon the hygienic production of milk. By this means the right type of man for milker has in many cases been found, while, in addition, by the example of one person, others have been stimulated to greater efforts. These competitions have also brought to the notice of wholesale and retail distributors, as well as to the general public, those persons who can and do produce better milk. Clean milk competitions are usually held under the auspices of County Agricultural Education Authorities in conjunction with the Ministry of Agriculture. Their main object has been to demonstrate that good quality milk which will keep well can be produced by conscientious farmers without expensive plant and specially constructed buildings. The usual conditions which applied were :

(1) The competition was usually spread over six or twelve months, one sample of milk being taken each month.

(2) Samples from the various competitors were taken on the same day at the same temperature. "Surprise" samples were also taken.

(3) The competition usually provided for three classes of competitors, as follows :

  (*a*) Competition for novices.

  (*b*) Competition for producers other than novices or graded milk licence holders.

  (*c*) Competition in which all might enter, but in which prizes could not be taken by holders of graded milk licences. Certificates were, however, awarded to such competitors.

(4) The judging was based on the bacteriological reports of the samples.

(5) Points and marks were given for :

	Marks.
(*a*) Bacterial Count	300
(*b*) Absence of *B. coli*	200
(*c*) Keeping Quality	300
(*d*) Sediment Test	100
(*e*) Buildings and Equipment	100
(*f*) Methods and Handling	400
(*g*) Health of Animals	100
Total	1,000

A clean milk competition was an educational aid to the producer, and aroused considerable interest among farmers. The best results were generally obtained where the producer himself worked and supervised production on the spot. It was also found necessary to educate the cowmen in addition to the producer. Prizes were often awarded to the cowmen employed by winners of the competition, and milkers were paid a bonus which rose or fell according to results. The workers were able to use any certificates they might win as recommendations when seeking new employment. The competitions were, as a rule, restricted to those producers within the boundaries of each county, but inter-county competitions have also been held.

A *Bacteriological Advisory Service* was established by the Ministry of Agriculture in conjunction with the various Agricultural Colleges many years ago, and has now been continued as part of the advisory service rendered essential by the advent of the National Milk Testing Scheme. Below is given a list of advisory officers who carry out this work and the areas served by them. These officials, besides carrying out certain duties under the scheme, hold themselves available to advise and assist producers and distributors in all matters affecting the milk supply. They will, if necessary, arrange for advisory visits to premises and examine any samples submitted to them. County Agricultural Organisers and Milk Officers are also available for advisory purposes by all producers and retailers, and their services have been greatly in demand following the inauguration of the National Milk Testing Scheme, careless producers receiving advice as to methods employed.

Other facilities for the examination of samples are provided at the various Public Health Schools attached to the Universities.

At several technical schools and institutes in large towns, courses for dairymen in the production and handling of clean milk are held. These courses deal generally with the hygienic aspect of clean milk production although in some areas lectures in milk processing are available for those interested in that aspect of the milk problem. An expansion of this work is vitally necessary.

Any details as to available educational aids would be incomplete without some mention of the service rendered to producers and distributors by the Public Health staffs of the country. They themselves have in many cases attended at some time or another courses in clean milk production and distribution held by the various Agricultural Colleges. They are therefore able to pass on their knowledge to the advantage of all concerned. The Public Health Committee of any Council, and particularly its officials, play a very important part in the control of milk supplies. They can educate the producer and should ensure that the milk is produced in a cleanly manner ; they have to supervise its distribution to satisfy themselves that milk so produced is maintained in a satisfactory condition ; and they have to educate the consumer as to the value of clean milk, its food value, and the way in which it should be stored. This, in addition to their ordinary duties which are becoming more and more involved, is a heavy responsibility when the enormous amount of milk produced annually in this country is considered.

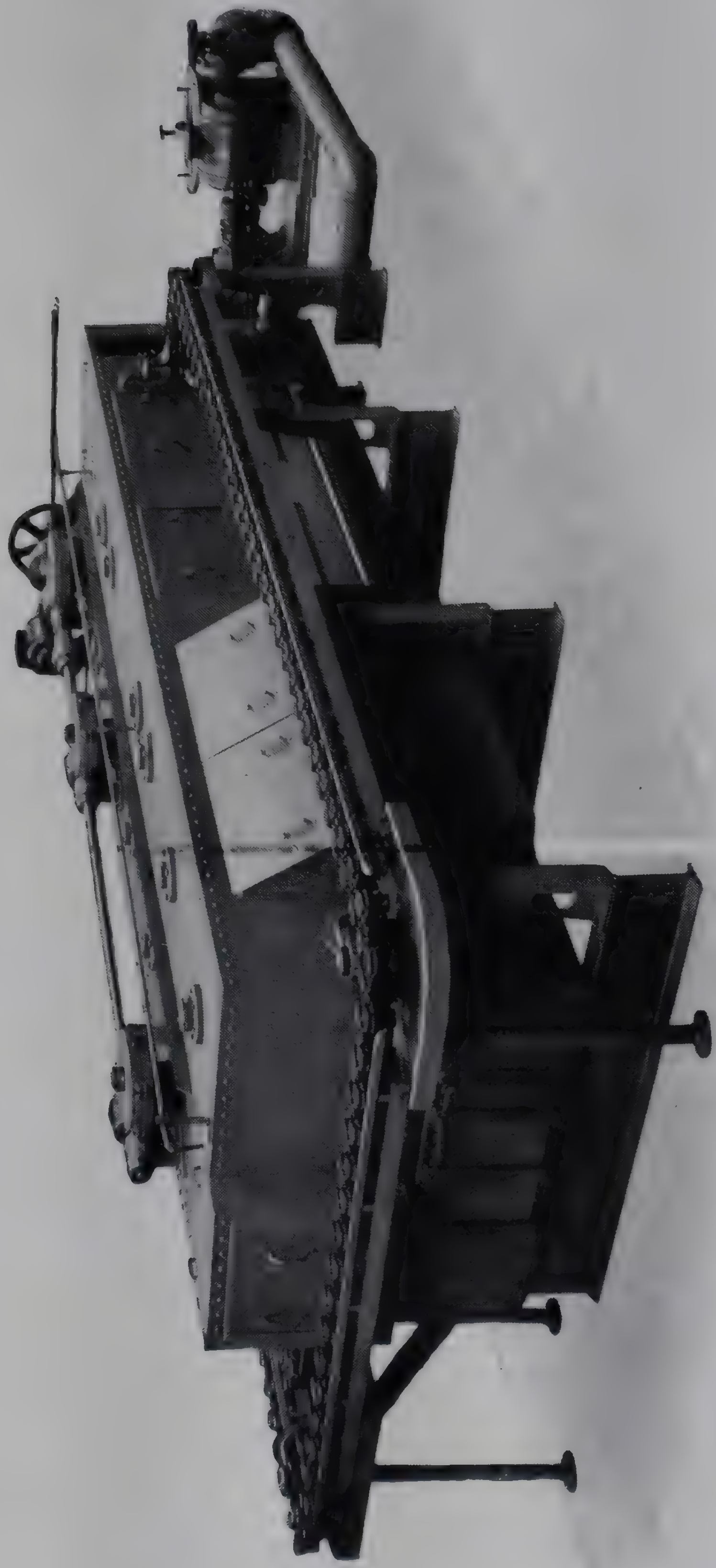
To carry out the work properly, interested Committees and keen officials are necessary. If one or the other is not sufficiently interested to take the necessary steps so essential to the proper control of the milk supplies, satisfactory results can hardly be expected. The officials concerned must of necessity be masters of their subject, especially as they will be dealing with practical men. Systematic education of the producer, the distributor, and the consumer is essential. The first step to be taken is the preparation of

LIST OF ADVISORY BACTERIOLOGISTS AND PROVINCES

Institution.	Counties served.	Address to which communications and samples should be sent.
King's College, Newcastle-upon-Tyne, 2	Cumberland, Westmorland, Durham, Northumberland.	C.H. Westwater, M.A., B.Sc., N.D.A., N.D.D., Dept. of Agriculture, King's College, Newcastle-upon-Tyne, 2
The University, Leeds, 2	Yorkshire—East, West and North Ridings.	D. A. McKenzie, B.Sc., N.D.A., N.D.D., Dept. of Agriculture, The University, Leeds 2
The Midland Agricultural College, Sutton Bonnington, Loughborough	Derby, Leicester, Rutland, Lincoln (Kesteven and Lindsey), Nottingham	A. Rowlands, B.Sc., M.S., Midland Agricultural College, Sutton Bonnington, Loughborough
School of Agriculture, Cambridge.	Hertford, Bedford, Cambridge, Huntingdon, Isle of Ely, Lincoln (Holland), Norfolk, E. Suffolk, W. Suffolk, Soke of Peterborough.	C. D. Oxley, M.A., School of Agriculture, Cambridge
South-Eastern Agricultural College, 39–41 Sackville Road, Hove, 3, Sussex	Kent, Surrey, E. Sussex, W. Sussex.	H. Barkworth, M.C., South-Eastern Agricultural College, 39–41 Sackville Road, Hove, 3, Sussex; South-Eastern Agricultural College, Wye, Kent.
National Institute for Research in Dairying, Shinfield, Reading.	Hampshire, Isle of Wight, Berkshire, Buckingham, Dorset, Middlesex, Oxford, Northampton	J. McClement, B.Sc., N.D.A., National Institute for Research in Dairying, Shinfield, Nr. Reading
Seale Hayne Agricultural College, Newton Abbot, Devon	Cornwall, Devon, Isles of Scilly	C. S. Morris, N.D.A., Seale Hayne Agricultural College, Newton Abbot, Devon
Agricultural Advisory Office, 22 Berkeley Square, Bristol, 8	Gloucester, Hereford, Wiltshire, Somerset, Worcester	J. W. Egdell, B.Sc., N.D.A., Agricultural Advisory Office, 22 Berkeley Square, Bristol, 8
Harper Adams Agricultural College, Newport, Shropshire	Stafford, Shropshire, Warwick.	A. Ll. Provan, B.Sc., Ph.D., Harper Adams Agricultural College, Newport, Shropshire
University College of North Wales, Memorial Buildings, Bangor, N. Wales.	Anglesey, Caernarvon, Flint and Denbigh.	Mrs. P. M. Hobson, N.D.D., University College of North Wales, Memorial Buildings, Bangor, N. Wales.
Dairy Buildings, University College of Wales, Llanbadarn Road, Aberystwyth.	Brecon, Radnor, Cardigan, Carmarthen, Merioneth, Monmouth' Montgomery, Pembroke, Glamorgan.	S. B. Thomas, M.Sc., Dairy Buildings, University College of Wales, Llanbadarn Road, Aberystwyth.
Cheshire School of Agriculture, Reaseheath, Nantwich.	Cheshire	R. G. Druce, Cheshire School of Agriculture, Reaseheath, Nantwich.
Essex Institute of Agriculture, Writtle, Chelmsford.	Essex	R. Robson, M.Sc., Essex Institute of Agriculture, Writtle, Chelmsford.
Institute of Agriculture, Hutton, Preston.	Lancashire	R. Burgess, M.A., Ph.D. Institute of Agriculture, Hutton Preston.

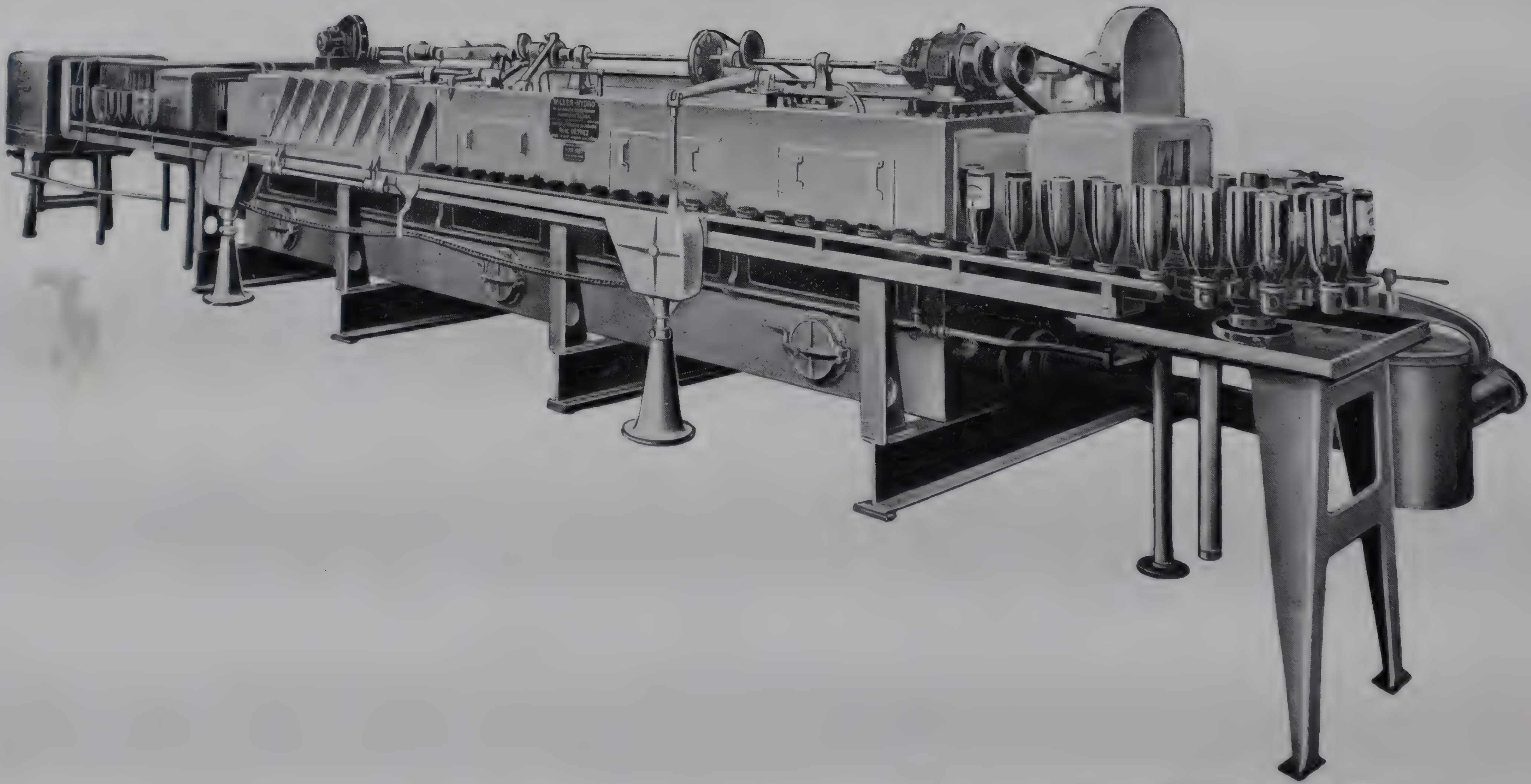
bulletins on clean milk production for the producer. These bulletins or pamphlets should be sectionalised, and should cover the whole aspect of production, step by step. When the producer has been sufficiently educated by the bulletins and by personal advice, the distributor should be instructed in a similar manner and, following him, the consumer. The education of those persons, when it has commenced, should not be allowed to lapse, but should be progressive and continuous, and anything likely to be of interest foreign bodies both before and after brushing. The apparatus is strongly constructed and a striking feature is the employment of brushes, a larger output of perfectly cleansed bottles being claimed by this means. A section of the apparatus is shown in Fig. 135.

(5) *The "Miller" Hydro.* These machines are manufactured in a variety of sizes useful for all types of dairies, as they can be obtained capable of treating up to 10,000 bottles per hour. They are entirely automatic in action and, of the larger sizes, two main types may be obtained. One of these employs brushes and gives the following treatment to each bottle :



By courtesy of the British Miller Hydro Co. Ltd.

FIG. 136. "Miller" Hydro Bottle-washing Machine.



By courtesy of the British Miller Hydro Co. Ltd.

FIG. 137. "Miller" Hydro Bottle-washing Machine.

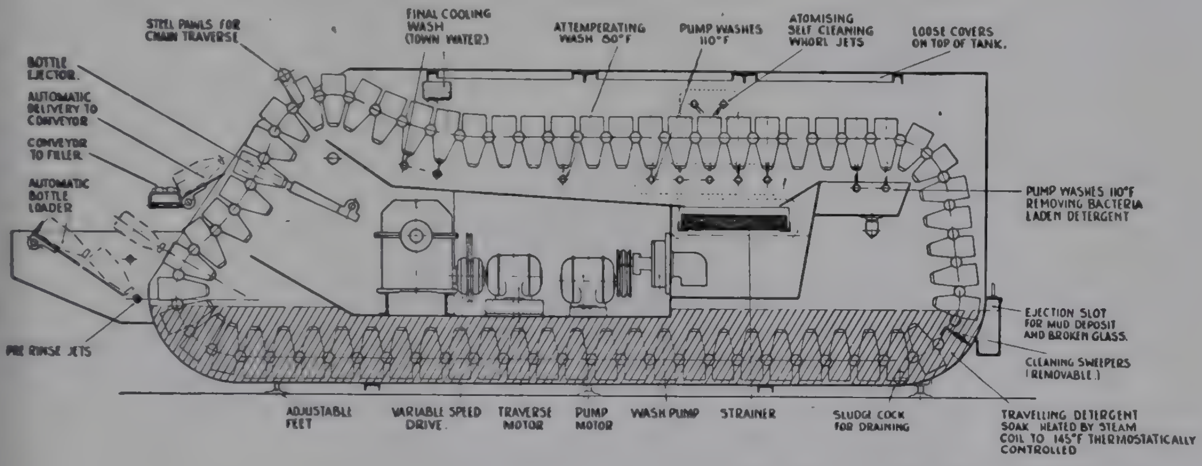
(*a*) Pre-rinse.
(*b*) Washed under pressure.
(*c*) Brushed and rinsed.
(*d*) Washed under pressure.
(*e*) Re-brushed.
(*f*) Sterilised.
(*g*) Hot rinse.
(*h*) Cold rinse.

The standard type gives five temperature changes during washing, finishing with steam, but a cold bottle can be delivered to the conveyor if desired. Both types possess self-cleansing jets and an efficient filtration system. A smaller but equally efficient machine of the rotary type is manufactured for use in smaller dairies.

(6) *The "A.D.E. Soakwasher."* This apparatus is designed to deal with from 2,000 to 10,000 bottles per hour, each container being given the following treatment :

(*a*) Pre-rinse of warm water under pressure.
(*b*) Warm detergent solution at 145° F. for several minutes.
(*c*) Two pressure washes with clean water at 110° F. to remove detergent.
(*d*) Five pressure washes at 110° F.
(*e*) Tempering wash at 80° F.
(*f*) Two final clean water washes at the temperature of the mains supply.

The machine is designed so that the access of wash water to the detergent tanks or detergent to the cleansed bottles is impossible. The conveyor chains are provided with cleansing appliances in order that broken glass and deposits may be removed from the detergent tank to escape through a slot into a container from which they can readily be removed. A section through this apparatus is shown in Fig. 138.


STEEL PAWLS FOR CHAIN TRAVERSE
FINAL COOLING WASH (TOWN WATER)
ATTEMPERATING WASH 80°F
PUMP WASHES 110°F
ATOMISING SELF CLEANING WHORL JETS
LOOSE COVERS ON TOP OF TANK.
BOTTLE EJECTOR.
AUTOMATIC DELIVERY TO CONVEYOR
CONVEYOR TO FILLER
AUTOMATIC BOTTLE LOADER
PRE RINSE JETS
PUMP WASHES 110°F REMOVING BACTERIA LADEN DETERGENT
EJECTION SLOT FOR MUD DEPOSIT AND BROKEN GLASS.
CLEANING SWEEPERS (REMOVABLE.)
ADJUSTABLE FEET
VARIABLE SPEED DRIVE.
TRAVERSE MOTOR
PUMP MOTOR
WASH PUMP
STRAINER
SLUDGE COCK FOR DRAINING
TRAVELLING DETERGENT SOAK HEATED BY STEAM COIL TO 145°F THERMOSTATICALLY CONTROLLED

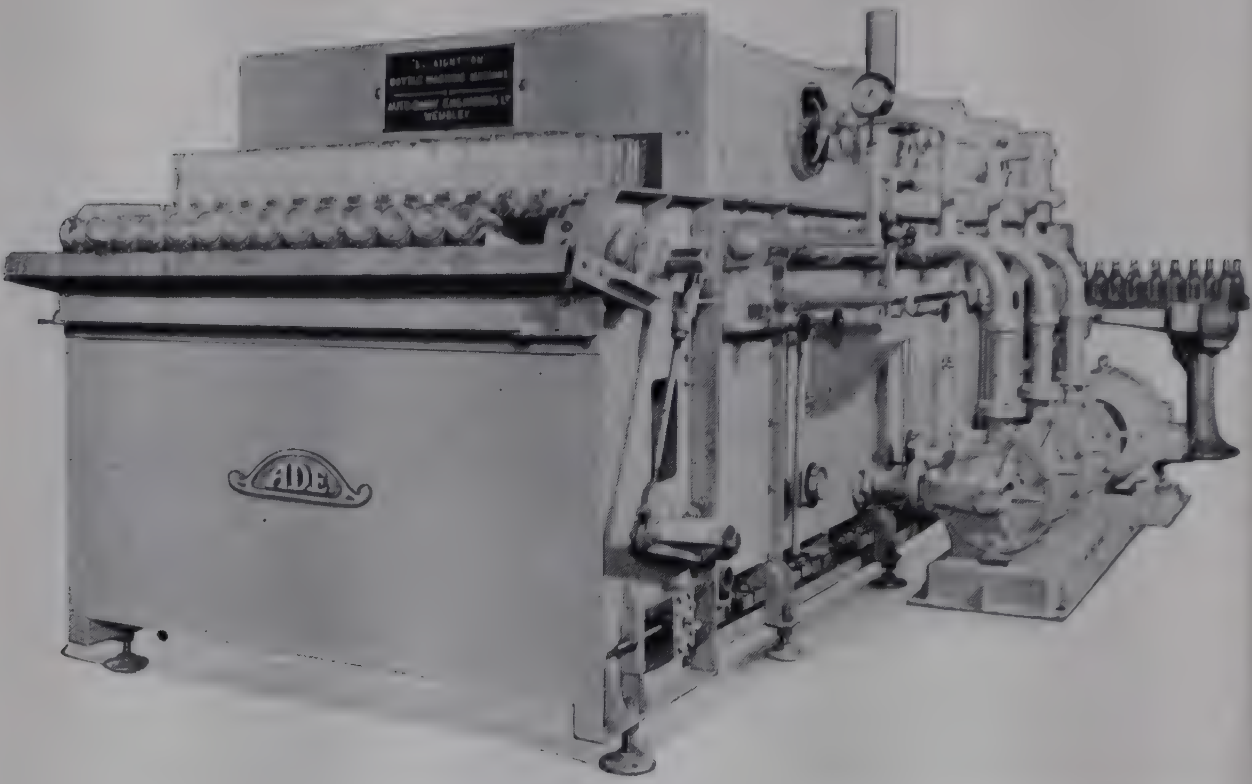
By courtesy of Auto-Dairy Engineers Ltd.

FIG. 138. "A.D.E. Soakwasher" Bottle-washing Machine.

(7) *The "A.D.E. Straighton" Washing Machine.* This is a unit designed to wash from 800 to 6,000 bottles per hour.

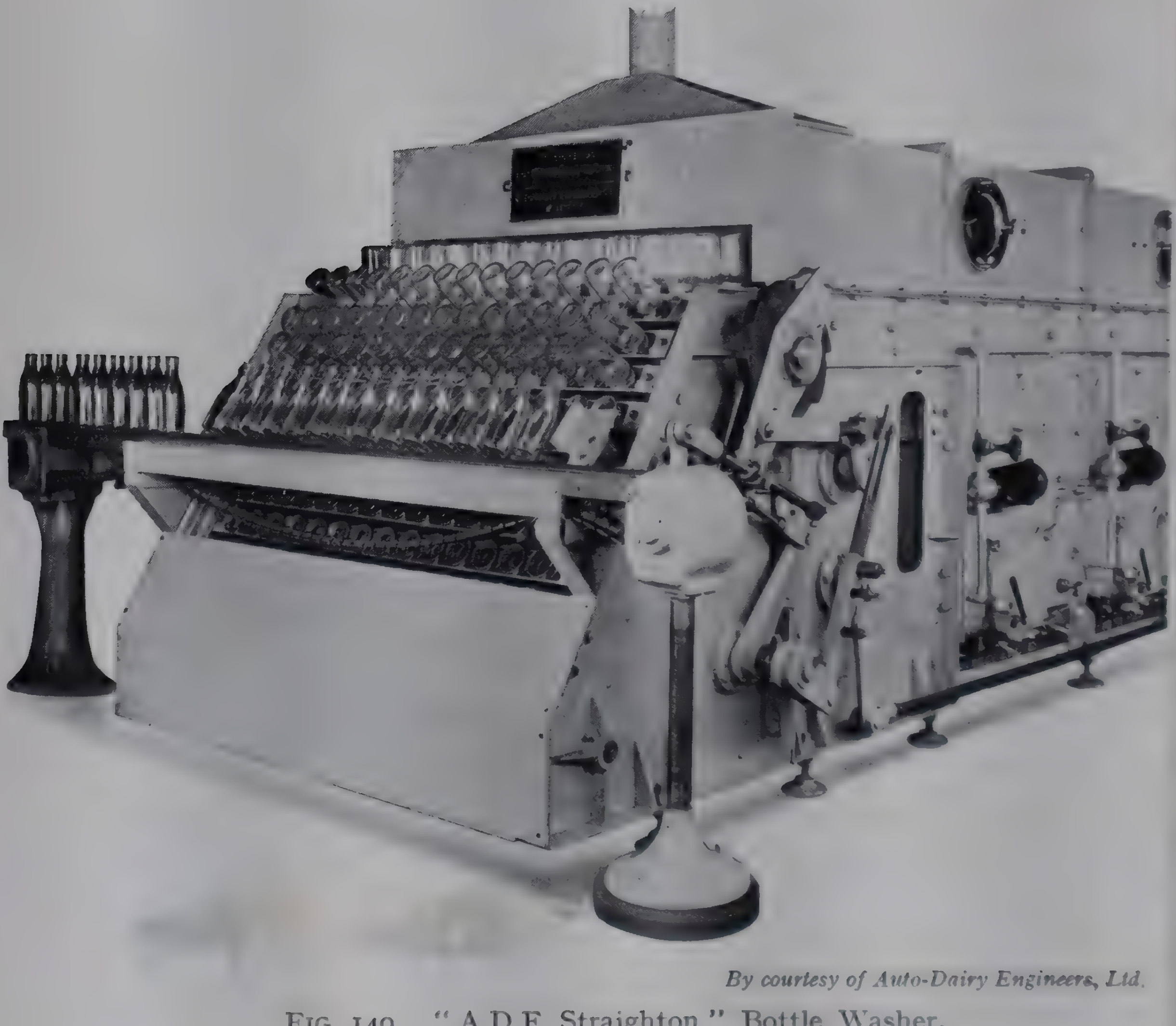
The machine provides a maximum of washing time while the bottle is being treated. The bottles are pre-rinsed and then washed fifteen times with detergent and water washes of steadily rising temperatures. This ensures complete removal of detergent from each bottle and minimises breakages due to temperature changes.

Ample drainage spaces are provided between washes, while each wash tank has a separate pump and filter through which all liquids must pass on their way to the jets. The spray pipes are fitted with special atomisers which give a high-powered rinse, outside surfaces receiving adequate treatment in addition. The wash tanks can be quickly drained and are fitted with self-acting thermostats for accurately controlling various temperatures. Gauge tubes are provided to show the height of the liquid in each tank together with plate glass inspection windows in the sides of the apparatus. Each of the larger machines is



By courtesy of Auto-Dairy Engineers, Ltd.

FIG. 139. "A.D.E. Straighton" Bottle Washer.
(Feed end showing pump side.)

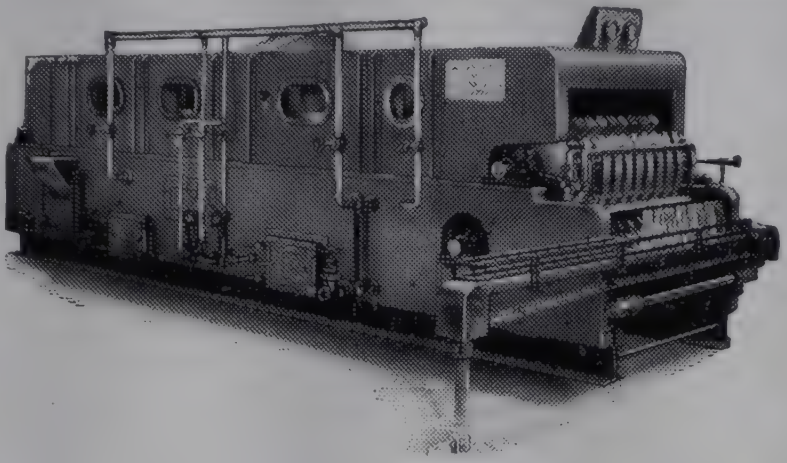


By courtesy of Auto-Dairy Engineers, Ltd.

FIG. 140. "A.D.E. Straighton" Bottle Washer.
(Delivery end showing heat control side.)

fitted with an automatic feeder for strong detergent solution which allows uniform strength to be maintained at all times. On leaving detergent compartments the bottles are washed several times with soft washes at gradually increasing temperatures, being finally dried with superheated steam at a temperature between 350° and 400° F. The apparatus is entirely automatic in action, and is designed so that bottle filling follows washing operations. This machine was produced to supply a hot bottle to receive hot milk prior to pasteurisation in bottle but a cold bottle may be delivered if desired, in which case the final jets are connected to luke-warm and cold waters to reduce bottle temperatures before filling takes place.

(8) *The "Dawson" Hydro-Bottle Washer.* This is a useful apparatus designed to deal with 1,000 to 10,000 bottles per hour, in various types, from one-third of a pint to quart size. It possesses a slow, mechanical, intermittent motion with positive centering of bottles over the jets. There is a gradual rise and fall of washing temperatures which are automatically controlled, dual pressure gauges and thermometers being grouped together on one panel. If desired, bottles may be delivered hot when they are to be filled with sterilised milk, in which case steam jets are substituted for the final cold rinse. Adequate filtration of the washing waters is provided. The feed is semi-automatic with positive automatic discharge of clean bottles.



By courtesy of Dawson Bros., Ltd.

FIG. 141. "Dawson" Super-hydro Bottle-washer and Steriliser.

(9) *The "GEM" Straight-through Washer.* This apparatus, illustrated in Fig. 142, is designed for the efficient treatment of large quantities of bottles. It is strongly constructed and will give the distributor long, efficient and care-free service. Satisfactory temperature controls are provided at all essential points.

As will be seen from the foregoing descriptions, there are a variety of machines to be obtained, which differ considerably in times of treatment and methods of application. The most variable factor and one which is probably the most frequent cause of contamination lies in the manner in in which machines are actually used. The factors chiefly subject to variation are :—

(1) Time during which the bottle is in the machine.

(2) Temperature of various washing solutions and, in some machines, temperature of the final rinsing solution.

(3) Detergent used for cleansing purposes and its percentage strength.

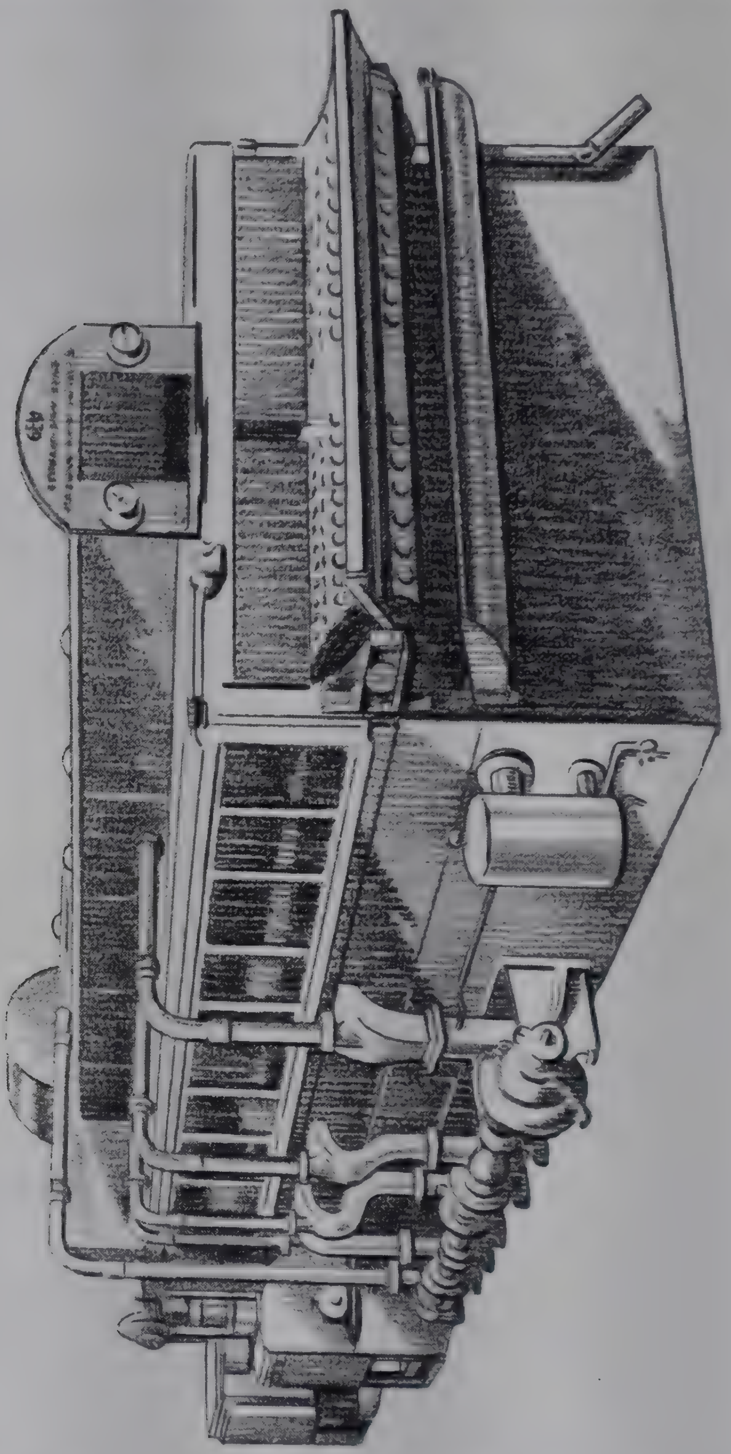
(4) Period during which detergent solution is in use and the methods used to maintain strength of such solution.

(5) Cleanliness of final rinsing water. (This is particularly important in machines which are designed to deliver cold bottles.)

(6) General cleanliness of the interior of the plant, including cleansing of all pipe-lines, water-ways, jets, etc. Water jets are easily blocked by scale if hard water is employed and, as mentioned previously, it is advisable to install a water softening apparatus unless soft water is already available, provision of which also makes for economy in detergent.

(7) Distance clean bottles have to travel to filling machine. As they travel mouths upward they are easily re-contaminated.

It will be found in practice that the general fault lies in the use of detergent solution which is of insufficient strength. Small amounts are often employed in making up the cleansing solution on the score of economy, while very often, even if the solution is sufficiently concentrated at the commencement of the run, no steps are taken to maintain its strength by addition of further detergent. When bottles leave the solution compartment, it is inevitable that they should carry away some solution, while leakages and splashing sometimes cause additional loss of strength. Some machines fail to maintain the detergent solution at a sufficiently high temperature, while very often, to prevent delays, bottles are passed through the washer before the solution has attained the necessary temperature. It is essential that those using bottling machines should formulate a definite working routine in order to ensure that every bottle treated by the apparatus may be regarded as safe.



By courtesy of the Graham Enock Mfg. Co. Ltd

FIG. 142. "GEM" Bottle-washing Machine.

Frequent examination of finished bottles is essential, but they should always be allowed to dry before such inspection is made. The efficiency of the process may be proved by pouring some warm distilled water into the bottle to be tested, followed by a few drops of phenol phthalein. The bottle should be well shaken and, if the liquid turns pink, alkali is present and this indicates that the bottle has not been properly rinsed. Bottles should be examined at frequent intervals for bacteriological cleanliness.

All washing machines require to be provided with efficient temperature recorders fitted to the various solution and hot water tanks, while the thermostatic control of such temperatures should be considered essential. In addition, adequate lighting is essential at loading and unloading points so that bottles may be properly inspected for dirt or other materials which may be adhering to their exterior or interior surfaces, before filling takes place.

Certain new methods of bottle cleansing are now the subject of experiment. Bottles, after washing, are subjected to dry heat sterilisation, while ultra-violet rays have been employed for sterilising purposes. Such methods must not, however, take the place of efficient washing, nor can any laxity in design of bottle-washing appliances be countenanced.

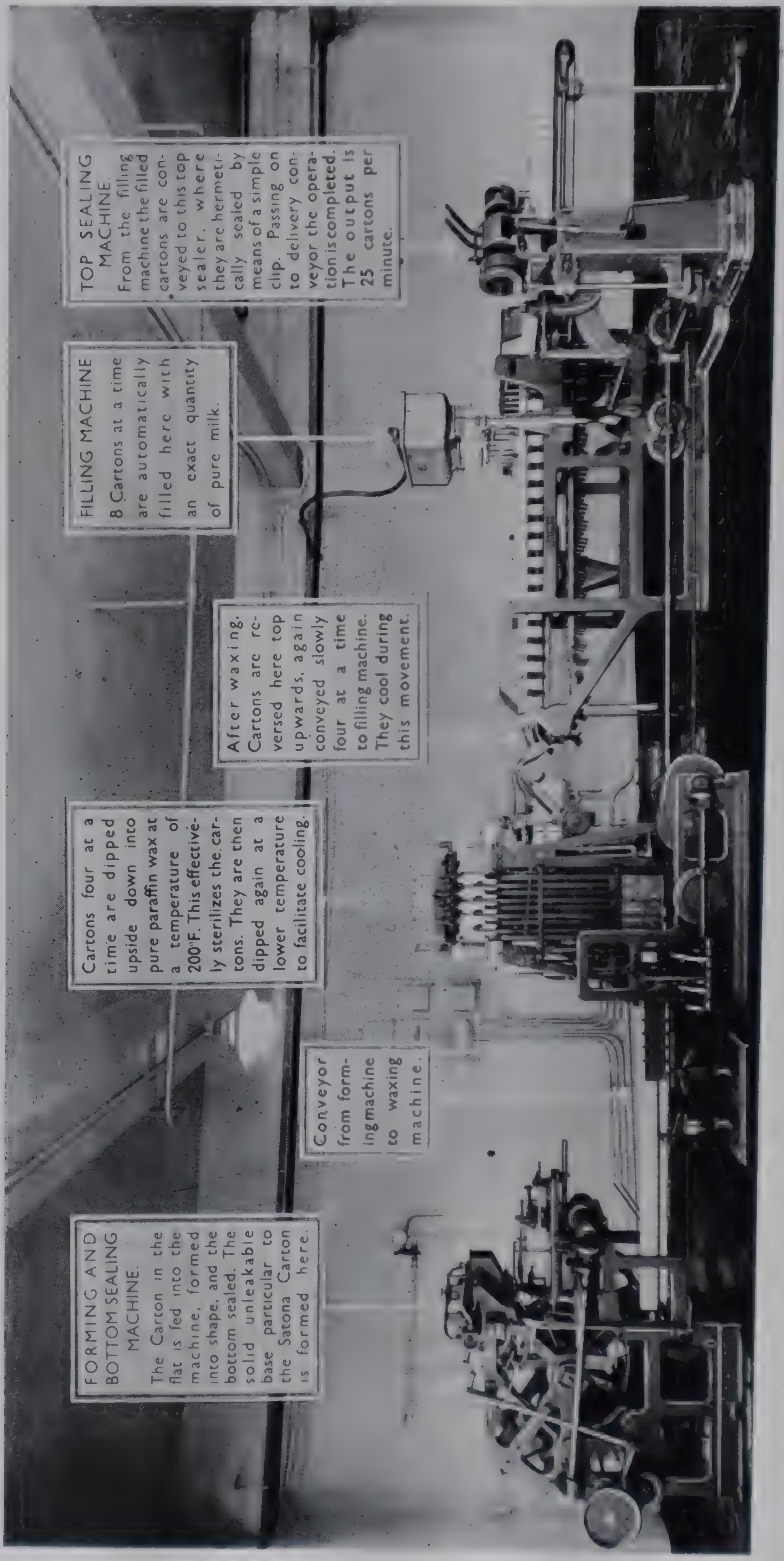
All bottle-washing machines require attention at the end of the day's run. Jets should be inspected for chokage and all *débris* and broken glass removed. Tanks require to be emptied, strainers cleansed and the correct centering of jets may need attention. Any large daily quantity of broken glass should be noted as this may be due to excessive temperature changes between the various sections. In such instances, temperatures should be checked against an instrument of known accuracy.

Crate Washing

Empty bottles are almost invariably delivered to the dairy in crates and, after the bottles have been removed and placed in the bottle-washing machine, the *crates* require attention. This may be done as follows. The crates are passed by a mechanical conveyor to the *crate washer*. This usually consists of a simple tunnel through which crates pass on a chain conveyor, washing and scraping operations being carried out by means of high-pressure caustic-soda solution during the journey through the machine. The final operation consists of washing in clean water before leaving the tunnel. The clean crates then pass to a table in close proximity to conveyors which carry the filled and capped bottles. These machines are usually found only in large dairies, the practice of the small distributors being to wash crates by hand. Where large numbers require to be dealt with, mechanical means of washing should always be provided as this ensures that crates are a credit to the owner instead, as is so often the case, becoming dirt traps and fly collectors.

Carton Containers

The system of delivering milk in *cartons* was practised by some distributors until the outbreak of war, and in many ways this method possessed decided advantages. War-time difficulties have, however, prevented the employment of cartons for milk delivery, but no doubt the advent of peace will see a rapid increase in the number used for this purpose. When this method was practised, milk, immediately on leaving the cooler at the farm or dairy, was filled into containers composed of parchment or card impregnated with wax which were assembled and sealed by machinery. Milk so contained was sold by many retail grocers, who stored the cartons in refrigerators until required. This system possessed one great advantage, in that milk was delivered untouched by hand, thus avoiding contamination during transit. From the retailer's point of view, the greatest advantage lay in the fact that empty cartons were non-returnable and were destroyed


FORMING AND BOTTOM SEALING MACHINE. The Carton in the flat is fed into the machine, formed into shape, and the bottom sealed. The solid unleakable base particular to the Satona Carton is formed here.
Conveyor from forming machine to waxing machine.
Cartons four at a time are dipped upside down into pure paraffin wax at a temperature of 200°F. This effectively sterilizes the cartons. They are then dipped again at a lower temperature to facilitate cooling.
After waxing. Cartons are reversed here top upwards, again conveyed slowly four at a time to filling machine. They cool during this movement.
FILLING MACHINE 8 Cartons at a time are automatically filled here with an exact quantity of pure milk.
TOP SEALING MACHINE. From the filling machine the filled cartons are conveyed to this top sealer, where they are hermetically sealed by means of a simple clip. Passing on to delivery conveyor the operation is completed. The output is 25 cartons per minute.

By courtesy of Satona Ltd.

FIG. 143. "Satona" Carton Making, Filling, and Sealing Machine.

by the consumer, loss through bottle breakages together with extra expense incurred in bottle washing being thus obviated.

In spite of this fact, the expense attached to the method (cartons cost approximately one half-penny each) prevented its adoption to any great extent, though no doubt extended use would result in cheaper production. The cost of an ordinary pint milk bottle if bought in large quantities was approximately 3*d*., its life being generally some ten to fifteen journeys. The overall cost was thus less than that of a carton. Some customers also complained of the peculiar taste of the milk, probably caused by contact with the carton, and refused to have their supplies delivered in this manner.

A new type of milk container, known as the "*Satona*" *carton*, had made its appearance in this country some years before the present war. The plant used in the construction of the container, as illustrated in Fig. 143, was a Danish invention, and one had been in operation for some time at the Danish State Experimental Farm. It consisted of four units coupled together, as follows:

1. Forming and Bottom-sealing Machine.
2. Apparatus for impregnating Cartons.
3. Filling Machine.
4. Carton-sealing Machine.

With this apparatus cartons are fed into the forming machine in a flat collapsed state. They are folded, the gummed edges fastened together, and the bases formed. They travel by means of a conveyor to the paraffining unit, being propelled into an elevator which carries four cartons simultaneously to the top of the machine, where they arrive in an inverted position. Here they enter the impregnating apparatus, where they are automatically dipped in paraffin wax at a temperature between 90° to 100° C. The cartons are next re-sprayed internally with wax at a lower temperature and, after the surplus material has drained away, are again inverted and travel by another conveyor in rows of four to the filling machine. Two rows of eight cartons are held stationary under the filler valves which are automatically lowered, the milk being released into them. The cartons then travel to the sealing apparatus. Here sealing clips are automatically affixed, pressure being applied to close these, while the sealing head is heated in order to seal completely the wax surface of the carton. This machine can deal with twenty-five filled cartons per minute in various sizes from one-third of a pint upwards.

All cartons must conform to certain requirements if they are to be satisfactory in use. These are:

(1) *Rigidity*. The container must stand up to the weight of its contents. This can be guaranteed by strengthening the carton at important points and by ensuring that it is of suitable shape.

(2) *Texture of Materials*. The cardboard should be composed of good, cellulose fibre. Strawboard should not be used.

(3) *Wax*. The wax must be pure and must not contain any material likely to taint the contents. It should be as white as possible and should not discolour the board during the impregnation process.

(4) *Waxing*. The degree of impregnation is important and this should be thoroughly carried out.

From an hygienic point of view, cartons are equally as good as glass bottles for use as milk containers.

MILK IN THE HOME

Given a clean supply of milk through the efforts of producer and distributor, this cleanliness requires to be carefully guarded by the consumer from the moment the product reaches the home. Expense is involved in production, collection, and distribution of milk under hygienic conditions, and a fair charge to the consumer is therefore justified. Milk produced and distributed with a minimum of care may be sold cheaply, but in the long run such milk becomes infinitely more expensive owing to impairment of the food value by contamination and improper treatment.

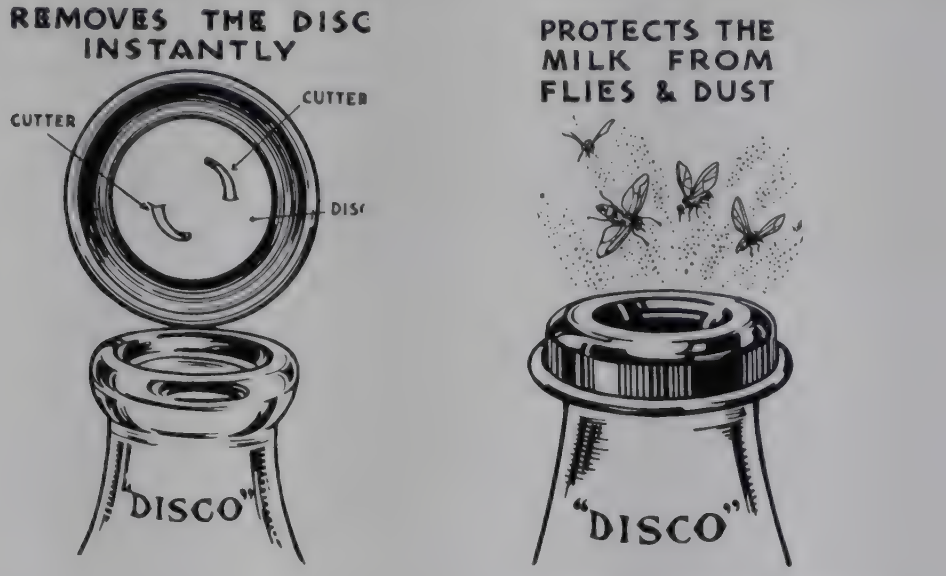
Average consumers, in their outlook on milk, suffer from a familiarity complex. They give little thought to the article, provided it appears satisfactory, tastes well, and is not sour ; and also provided the price suits their pocket. They sometimes do not even desire cooled, bacteria-free milk, preferring to receive the product in its natural, warm state. As the temperature of milk has a direct bearing upon the growth of any bacteria which it may contain, every effort should be made to discourage the demand for such milk. Furthermore, as has already been pointed out, consumers are often averse to receiving milk in bottles, because they think they are not receiving sufficient for their money.

It is only fair to producers to state that serious blame lies at the door of the consumer for premature souring of milk, since they do not, as a rule, take any precautions to ensure that the product is kept sufficiently cool after delivery, although there are places in every house where milk may be adequately stored. Milk, whether delivered loose or in bottles, is frequently left for hours in uncovered receptacles which have not been adequately cleansed. Again, the bottle itself is often stored in some overheated cupboard or other undesirable situation. The souring of milk in the home through pollution by flies alone is enormous. The consumer responsible for this state of affairs is generally the first to grumble at this change in the liquid, blaming the producer or the distributor for the losses which ensue. As an essential part of the control of milk supplies, every effort must therefore be made to enlighten the consumer on this subject, as there can be no point in educating producer and distributor, only to find their efforts dissipated by negligence of the ultimate user. Details as to such education have already been supplied (see page 191).

A suitable place for the storage of milk in the home is essential, and such storage place should be cool and clean. As soon as possible after milk has been delivered it should be placed in some such situation until required for use. Adequate larders are not always available. In many smaller houses the food cupboard, often unventilated, is found in close proximity to the kitchen firegrate. The absence of a proper food-store should not be used as an excuse for improper storage of milk, as other more suitable storage can often be found or constructed. One of the best improvised storage places can be made at negligible cost from fly-proof wire gauze or perforated zinc in the form of a small cupboard. This can be fixed on a wall which faces in a northerly direction to prevent excess of sunlight. Milk is not, however, protected from dust by the use of fly-proof gauze, while flies may gain admittance to the cupboard when the door is opened. It is therefore essential that the milk should be covered.

In districts where the liquid is sold loose it has to be stored in jugs and basins, and in such instances particular care should be taken to ensure that utensils permit of easy and thorough cleansing. If milk is delivered in bottles, the bulk of the milk should be kept in the bottle until required, covered by the cap or disc supplied with the article. Sufficient milk for immediate use can be poured into a small jug for table purposes. The mouth and neck of the bottle should also be carefully wiped with a clean cloth before being emptied, unless the upper portion has been protected by means of a cap.

There is now on the market a patented proprietary article known as the "*Disco*" *milk bottle disc remover and cover,* which may be purchased for a few coppers. The makers claim for it the following advantages :

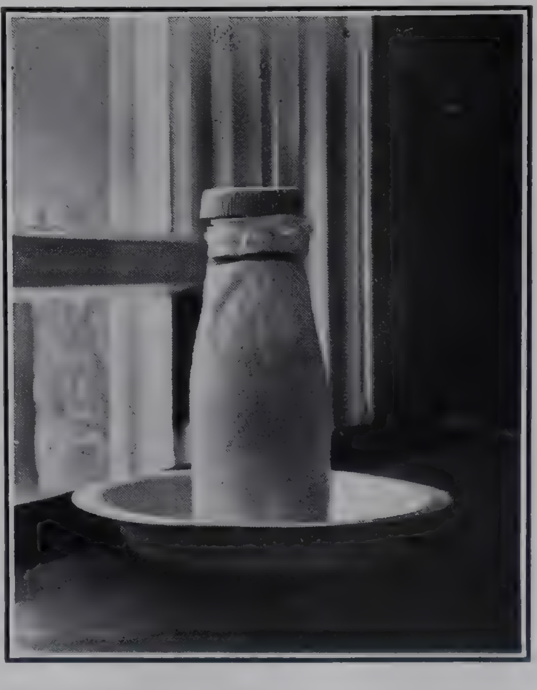

REMOVES THE DISC INSTANTLY
CUTTER
CUTTER
DISC
"DISCO"
PROTECTS THE MILK FROM FLIES & DUST
"DISCO"

By courtesy of Sutherland Thomson & Co.

FIG. 144. "Disco" Milk Bottle Disc Remover and Cover.

(1) Saves Splashing.
(2) Saves Time and Trouble.
(3) Covers the Bottle Adequately.
(4) Opens the Bottle Quickly.

The use of this article is definitely to be recommended. The cover is pressed over the top of a sealed bottle and, by means of two cutters on the under surface, the disc is pierced. On lifting the cap, the disc is also removed, leaving the bottle ready for pouring. After pouring, the cap is reinserted. This automatically replaces the dics in position, thus affording double protection for the milk.



By courtesy of the Tuberculin Tested Milk Producers' Association.

FIG. 145. Storage of Milk in the Home.

It is advisable during hot weather to stand any vessel or bottle containing milk in a basin of water, such water being frequently renewed. A piece of flannel covering the receptacle or wrapped round the bottle, as shown in Fig. 145, with the extremities actually in the water, is an additional aid towards retaining the milk at a low temperature.

The consuming public has long been under the impression that milk will not keep unless air has access to it. This dangerous fallacy has now been exploded, although it dies hard. Jugs should be covered with slips of glass, or improved protection may be obtained by the use of inverted saucers or plates. Bottles may be suitably covered with cups or tumblers inverted over the neck. The disc supplied with the bottle may be used, or the " Disco " cover previously mentioned. A slip of paper placed over the neck and secured by means of an elastic band forms yet another method of protection. The use of muslin or cheese cloth covers is not to be recommended. These covers are difficult to cleanse, require frequent washing. and do not yield the necessary protection against contamination by dust.

All receptacles used for the storage of milk should be kept scrupulously clean, while the ultimate containers should never be dusty or soiled. After use, such articles should first be rinsed in cold water—if the preliminary rinsing is not carried out traces of milk adhere to the sides of the vessel and are difficult to remove—then washed in hot water, and finally scalded. They should never be wiped with a cloth which has been used for other household dishes. A little washing soda may be added to the hot washing water if desired, but, if this is done, a further rinsing with clean hot water is necessary before scalding takes place. Milk bottles should always be thoroughly washed before being returned to the roundsman. After cleansing, milk receptacles should be stored in an inverted position in a clean place until required for further use.

It is essential that milk should not be stored in an uncovered condition in proximity to any strong-smelling substances as it will readily absorb such odours. New milk should never be mixed with old milk unless the whole is to be used immediately, since old milk is likely to contain a larger number of bacteria, when, if the weather is hot, souring will quickly take place.

CHAPTER VIII

DESIGNATED MILKS

The History of Designated Milks

THE milk supplies of the country may be divided into three sections, as follows :

(1) Designated milks.

(2) Milks treated by heat. Pasteurised milk is designated as such, but the processing requires detailed consideration which will be found set-out in Chapter IX.

(3) Raw Milk of varying quality.

The grading of milk was first recognised and became operative during the War of 1914–18, when the food supplies of the country were controlled. This grading, however, could not be properly compared with the grades at present in force, which were specified in the Milk (Special Designations) Orders of 1923 and 1934, and are now set out in the Orders of 1936 to 1943.

During the last War, the Ministry of Food controlled the producers' price for milk. This price was eventually found to be insufficient to meet the needs of those persons who, by their methods and outlay, were producing a milk superior in quality to the average supply. In an attempt to prevent any inequity, a simple grading system was inaugurated in September, 1918, although the licences issued under the Scheme specified no definite grade or standard. In March, 1920 two grades of milk were introduced to be sold under licences A and B. December, 1920 saw the introduction of a further scheme, still comprising two grades. There were Grade A (Certified), for which a bacteriological standard was laid down, and Grade B, for which no standard was specified. In 1922, a further advance in the grading system was introduced. The designations then specified were :

(1) Certified Milk.	Raw Milks.
(2) Grade A Milk.	
(3) Pasteurised Milk.	Milk treated by heat.

Certified milk had actually been mentioned previously in Section 1 of the Milk and Dairies (Consolidation) Act, 1915, which gave the Minister of Health power to make an Order prescribing the conditions under which milk of this grade might be produced and distributed. The operation of this Act was, owing to the War, suspended until some future date to be fixed when hostilities were over, and it had not come into operation when the Milk and Dairies (Amendment) Act, 1922 became law. Under this latter Act, the aforementioned three grades of milk were specified, the Act being introduced to defer the commencement of and to amend the Act of 1915.

The amending Act of 1922 empowered the Minister to introduce certain grades of milk by means of an Order. This was carried out in the Milk (Special Designations) Order, 1923, when the following grades were designated :

(1) Certified.	Raw Milks.
(2) Grade A (Tuberculin Tested)	
(3) Grade A	
(4) Grade A (Pasteurised)	Milks treated by heat.
(5) Pasteurised.	

The Order of 1934, while continuing these designations, introduced certain changes as regards the authorities responsible for granting of licences for the production of Certified and Grade A (Tuberculin Tested) milks, the Minister of Health relinquishing his power to grant licences for these grades of milk in favour of County and County Borough Councils.

When the Order of 1923 first became operative, many people were of opinion that it would serve very little purpose and would benefit only the favoured few who were able to put a small quantity of milk on the market, such milk to be purchased by food fanatics and other faddists. It has been found, however, that such criticism was without justification and that the production of raw graded milk has served the very useful purpose of protecting and encouraging these enterprising dairy farmers who possess good, healthy herds, modern cowsheds, and dairies, who produce milk in a scientific manner, and who should therefore be entitled to a better market than the careless producer who gives no thought to the manner in which his milk is produced and handled. The production of such milk is not at present compulsory, although the Minister of Food has acquired power under the Defence (General) Regulations, 1939 (55G), (see pages 435 to 436), to issue Orders in this respect for specified districts. Any farmer who is sufficiently enterprising and who wishes to sell milk as a designated product, can obtain a licence to produce such milk, the conditions of which must be faithfully observed. The Order of 1923 resulted in the fostering of a class of individuals possessing enterprise and initiative who have set an example to their neighbours, with subsequent benefit to the entire milk industry.

The fact that production of graded milks was voluntary, coupled with the fact that there was little public demand for the product, induced only a very small proportion of the milk producers of the country to produce such milk. The number of those producing raw, designated milks has, however, gradually increased, and since extra financial aids were offered for the production of such milks, there has been a sharp upward rise in the number of raw, designated milk producers. In 1943, the total annual sales of Tuberculin Tested milk amounted to 6 per cent. of milk produced in the country, while Accredited milk accounted for a further 35 per cent. Twenty-two per cent. of the Tuberculin Tested milk was sold by wholesalers. The quantity of milk sold under the designation " Accredited " was negligible, the bulk of this grade being either pasteurised or mixed with other supplies. It is none the less true to state that by far the greater number of licensed designated producers are marketing Accredited milk. This is doubtless due to the fact that production of such milk does not entail freeing the herd from tuberculosis, while provided the owner possesses fair buildings and uses sound methods in handling the animals and the milk after production, it is easily within his power to produce this grade.

The Milk (Special Designations) Order, 1936, revoked the two existing Orders of 1923 and 1934. It had two main objects in view, as follows :

(1) To transfer from the Minister to certain Local Authorities (County and County Borough Councils) the duty of granting producers' licences for certain types of graded milks (Tuberculin Tested and Accredited).

(2) To improve and simplify the designations at present in force.

It does not appear by any means certain that the new Order will solve the problem of designated milks.

Present Grades of Designated Milks

The present designations under which milk may be sold are :

(1) Tuberculin Tested. (Amalgamates "Certified" and "Grade A (Tuberculin Tested)".)
(2) Accredited. (Replaces "Grade A".)
(3) Pasteurised. (This type of milk is dealt with more fully in Chapter IX.).

As will be seen, three main grades are specified. This would constitute a real simplification if other sub-designations were not allowed by Schedule 3, Part 1, of the Order. Thus, if "Tuberculin Tested" milk is bottled at the point of production, the word "(Certified)" may be added. If the same milk is pasteurised, then the word "(Pasteurised)" may be used. Again, the designation "Accredited Milk (Farm Bottled)" may be employed if such milk is bottled at the point of production. It will be seen, therefore, that, in addition to the three main designations, three sub-designations may also be used. It should be noted that a dealer selling "Tuberculin Tested (Pasteurised)" milk, which is not strictly speaking a designated milk although certain standards are specified with which it must comply, will require to obtain the appropriate licences in respect of the designations "Tuberculin Tested" and "Pasteurised." The principle underlying these designations is to ensure that those members of the consuming public who wish to obtain an improved supply, can do so. This has been facilitated by a general reduction in the retail price of such milks at the behest of the Minister of Food.

General Conditions for Grant of Licences

Certain conditions have to be complied with both by the producer and the distributor, while the milk produced has to attain a specified standard before the necessary licences are granted. The general conditions affecting the production and distribution of such milks are :

(1) The arrangements and processes under and by which the milk is produced, stored, treated and distributed shall be such as to satisfy the licensing authority that the requirements of all Acts and Orders relating to Milk and Dairies and the requirements of this Order are being and will be complied with.

(2) Adequate measures have to be taken to ensure that such milk is kept apart from all other milk at all times except when it is in sealed containers. Any vessel or apparatus which has at any time been used for any other milk shall be thoroughly cleansed and sterilised on each occasion before being used for containing graded milks, and no room or compartment of a dairy shall be used for designated milks and any other milk unless each type of milk is in a sealed container.

(3) Subject to the provisions of the Order, the licence holder shall not for the purpose of any sale or advertisement of the designated milk in question refer to it by any designation which would suggest that it is tested, approved or graded by any competent person.

(4) The licence holder shall :
  (*a*) Keep accurate records of the quantities of milk produced, purchased and sold, and of the names and addresses of the persons from whom the milk was purchased and to whom it was sold otherwise than by retail.
  (*b*) Permit any person duly authorised by the licensing authority—
    (i) to inspect the processes of production, storage and treatment;
    (ii) to take samples of the milk free of charge, and
    (iii) to inspect any records which the licence holder is required to keep.

Certain recommendations have been made by the Ministry of Health with regard to the granting of licences. Before any new licence is granted, the licensing authority should require the producer to submit one or more samples of his milk for laboratory examination. The farm should be inspected, particular attention being paid to the methods of milking and sterilisation of utensils, containers or bottles. In deciding the suitability of premises, the requirements of the Milk and Dairies Order, 1926, should be taken as a *minimum* standard. It has been particularly emphasised that County Councils should work in close co-operation with District Councils for the administration of the Order, while care should be taken to ensure that premises and methods are such as will enable the producer to comply regularly with the prescribed standard for the grade of milk to be produced.

Note is made of the fact that in the past considerable divergence has existed between the requirements of the various licensing authorities. No fixed code of requirements applicable to every authority has been laid down, although it is emphasised that more uniformity is essential. It is unfortunate that more guidance has not been given on this point, as the weakness, indeed danger, of varying standards must be obvious to anyone engaged in the control of milk supplies. It is recommended that sources of supply should be verified before any licence is granted to a dealer, while the processes employed at dealers' premises, together with the records of milk purchased and sold, should be frequently inspected.

The responsible bodies for the issue of the various licences, including those for pasteurisation set out in the Order, vary according to the designation of the milk, and are as follows :

(1) "Tuberculin-Tested." .	Common Council of the City of London, Metropolitan Borough Councils, and County and County Borough Councils.
(2) "Accredited." . .	As above.
(3) "Pasteurised" . .	All Councils.
(4) Supplementary Licences for any of the above.	All Councils.

Under the terms of the Food and Drugs (Milk and Dairies) Act, 1944, licences for the production of raw designated milks will be granted by the Minister of Agriculture and Fisheries when this Act becomes operative.

The granting of licences has raised several problems. In some cases, authorities concerned have given too little consideration to essential requirements, while in other instances the standard required has been fixed at such a high level as to be entirely unreasonable. In many instances buildings appear to have been approved with similar lack of care.

Special Conditions for Grant of Licences

(1) Tuberculin Tested Milk

The following conditions apply to producers only :

(i) (*a*) Every animal of the herd shall be submitted to a tuberculin test at an interval of not less than two and not more than six months after the last preceding test of such animal, and an animal born and bred in the herd shall be submitted to such a test before it attains the age of twelve months. An inspector may make a special tuberculin test of any animal in the herd at an interval of not less than two months after the last preceding test of such animal, or, if the animal has not previously been submitted to a tuberculin test, at any time. No animal shall be added to the herd unless it has passed the tuberculin test within fourteen days before it is so added or, in the case of an animal taken directly from an attested herd or a herd in respect of which a licence authorising the use of the special designation "Tuberculin Tested" is in operation, on the occasion of the last test in that herd. When an animal other than an animal taken from any such herd as aforesaid is added it shall be segregated from the rest of the herd for a period of two months from the date of its addition and submitted to a further tuberculin test on the expiration of that period :

Provided that in the case of an attested herd in lieu of the above conditions the conditions prescribed in the arrangements made in that behalf by the Minister of Agriculture and Fisheries shall be complied with.

(*b*) The condition of every tuberculin test made by a private veterinary surgeon shall be sent to the licensing authority within seven days after the completion of the test (or in the case of animals added to the herd, within seven days after such addition).

(*c*) No animal in the herd shall be injected with tuberculin except on the occasion of the prescribed tuberculin tests. No such animal shall be inoculated or vaccinated against tuberculosis or with live *Brucella abortus* without the consent of the Minister of Agriculture and Fisheries.

(*d*) Where any animal is certified as reacting to a tuberculin test it shall forthwith be removed from the herd.

(*e*) All animals in the herd shall be suitably marked for purposes of identification and a complete register of such animals shall be kept.

(ii) Every animal of the herd shall be submitted to an examination at intervals of not more than six months, and in the case of an examination made by a private veterinary surgeon the veterinary surgeon's certificate shall be sent to the licensing authority within seven days after the date of such examination.

(iii) Where an animal is certified as showing evidence of any disease which is likely to affect the milk injuriously it shall be segregated from the rest of the herd or removed from the herd as the case may require and the special designation shall not be used in relation to its milk.

(iv) A record shall be kept of all animals segregated from the rest of the herd in pursuance of any of the foregoing conditions, showing the reasons for the segregation or removal, and in the case of removal, the manner in which the animal has been disposed of.

(v) The herd shall be completely isolated from all other cattle.

(vi) The milk in relation to which the special designation is used, unless it is bottled by the producer in accordance with the procedure for bottling hereinafter specified, shall be consigned from the dairy where it is produced in unventilated sealed containers which shall be labelled or marked in a suitable manner with the address of the dairy, the day of production (with the word "morning" or "evening" added according to the time of milking), and the words "Tuberculin Tested Milk."

The following conditions apply to all dealers, whether producers or not, by whom the milk is delivered to the consumer :

(i) The milk in relation to which the special designation is used, unless it is delivered to the consumer in the containers in which it is received, the seals being unbroken, shall be delivered either in bottles or in other suitable containers of not less capacity than two gallons. For this purpose the term "bottle" includes any container of a capacity not exceeding one quart and of a type approved by the licensing authority granting the licence for the establishment at which the milk is bottled.

(ii) Every bottle containing the milk shall be tightly closed and shall be securely fastened either with a cap overlapping the lip of the bottle, or in some other suitable manner approved by the licensing authority. The cap shall bear the address of the bottling establishment and the words "Tuberculin Tested Milk," and it may also bear :

- (*a*) The day of production with or without the word "morning" or "evening" according to the time of production.
- (*b*) The name of the dealer by whom the milk was bottled.
- (*c*) The words "Produced from cows which have passed the tuberculin test," and
- (*d*) if the milk has been bottled at the place of production, the word "(Certified)."

Except with the consent of the licensing authority the cap shall bear no other words.

If there is no cap on which the wording can be suitably placed, it shall be placed within a surrounding line in a prominent position elsewhere upon the container, and the foregoing provisions shall apply.

(iii) Where containers other than bottles are used, every container shall be closed with a tightly-fitting cover and shall be suitably sealed and labelled.

The following conditions apply to all dealers, whether producers or not:

(i) The milk in regard to which the special designation is used shall not at any stage be treated by heat or in any other manner likely to affect its nature or qualities, except that where a licence authorising the use of the designation "Pasteurised" in relation to such milk has been granted the milk may be treated in accordance with the conditions of such licence, and where it is so treated the word "(Pasteurised)" shall be added after the words "Tuberculin Tested Milk" wherever such words are used in connection with the sale or advertisement of the milk or the labelling or marking of receptacles containing the milk. In the labelling or marking of receptacles the word "Pasteurised" shall be printed in block letters which shall not be smaller than the letters used for the words "Tuberculin Tested Milk."

(ii) The milk which is not pasteurised shall be treated under such conditions that:

- (*a*) any sample of milk in relation to which the special designation is used; and
- (*b*) any sample of milk from the herd in respect of which a licence authorising the use of the special designation is in force (whether the designation is used in relation to that milk or not), if the sample is taken before the milk has been placed in bottles or other containers for delivery to the consumer and either while it is in the possession of the producer or before the containers in which it is consigned to another dealer are opened by that dealer

shall satisfy a methylene-blue reduction test and shall be found to contain no coliform bacillus in one-hundredth of a millilitre. The tests shall be carried out in such a manner as the Minister may direct:

Provided that before such testing is begun any sample to which paragraph (*b*) above applies shall be kept at atmospheric temperature until 6 p.m. on the day of production if it is from a morning milking, and until 10 a.m. on the next day if it is from an afternoon milking, and any other sample may be kept at atmospheric temperature for a period not exceeding two hours. If the test is not then immediately begun the milk shall be cooled and kept at a temperature from 32° to 40° F. for a further period not exceeding eighteen hours, and the test shall be begun at the end of that period.

(iii) A sample taken at any date from the 1st May to the 31st October shall be regarded as satisfying the methylene blue reduction test if it fails to decolourise the methylene blue in four and a half hours and a sample taken at any date from the 1st November to the 30th April shall be regarded as satisfying the test if it fails to decolourise the methylene blue in five and a half hours.

(2) Accredited Milk

The following conditions shall apply to producers only:

(i) Every milch cow shall be submitted to an examination at such times and as often as may be required by the Minister of Agriculture and Fisheries not being less often than once a year and in case of an examination made by a private veterinary surgeon the veterinary surgeon's certificate shall be sent to the licensing authority within seven days after such examination.

(ii) This condition is similar to that set out in paragraphs iii and iv which are applicable to producers of Tuberculin Tested milk (see page 241).

(iii) The herd shall not at any time contain any animal which to the knowledge of the producer had before its introduction into the herd been tested with tuberculin and had reacted to the test.

(iv) This condition is similar to that set out in paragraph i (*c*) which is applicable to producers of Tuberculin Tested milk (see page 241).

(v) The cows in milk belonging to the herd shall be kept separate from all other cows in milk.

(vi) Similar to paragraph vi of the conditions applicable to the production of Tuberculin Tested milk (see page 241).

The following conditions apply to all dealers, whether producers or not, by whom the milk is delivered to the consumer :

(i) Similar to paragraph i which is applicable to dealers in "Tuberculin Tested" milk (see page 241).

(ii) Similar to paragraph ii of the conditions affecting dealers in Tuberculin Tested Milk (see page 241). In the case of Accredited milk bottled at the place of production, the words "Farm Bottled" may be added to the designation set out on the cap.

(iii) This paragraph is similar to paragraph iii of the conditions applicable to dealers in Tuberculin Tested milk (see page 242).

The following conditions apply to all dealers, whether producers or not :

(i) The milk in relation to which the special designation is used shall not at any stage be treated by heat or in any other manner likely to affect its nature or qualities.

(ii) Details the bacteriological standards to which samples of Accredited milk shall attain. These are similar to those for Tuberculin Tested milk set out on page 242.

The amendments set out in the Order of 1938 and 1943 have been incorporated in the conditions detailed above. The Order of 1936 also sets out the conditions under which pasteurised milk may be produced and sold. These will be found in Chapter XI, page 261.

The Minister of Health has drawn attention to the fact that where a herd is entered on the Register of Attested Herds kept by the Minister of Agriculture and Fisheries, the conditions relating to such herds shall apply in lieu of the conditions applicable to tuberculin tested herds. The results of tuberculin tests carried out in respect of Attested Herds which are licensed for the production of Tuberculin Tested milk are communicated to licensing authorities by the Minister of Agriculture and Fisheries. The tests are carried out by veterinary inspectors appointed by the Minister of Agriculture and Fisheries, or by private veterinary surgeons. They are made at intervals of not less than two or more than six months *at the discretion of the producer*. It is stated that this modification has been introduced in order to facilitate the eradication of bovine tuberculosis from dairy herds. Animals brought from an Attested Herd into a herd licensed for the production of Tuberculin Tested milk or from herds producing this grade of milk must be tested upon arrival and segregated from the remainder of the herd for two months. At the expiration of this period, such animals must be retested before being admitted to the herd. At a later stage, registration under the Attested Herds Scheme may be made an essential condition for the granting of a licence to produce Tuberculin Tested milk. In addition to tuberculin tests, all herds must be clinically examined at intervals of not more than six months by a veterinary inspector.

Animals producing Accredited milk must be clinically examined at intervals of not more than three months if the milk is to be sold in its raw state ; and at intervals of not more than twelve months if the milk is to be subsequently heat-treated. This was recommended by the White Paper : "Measures to Improve the Quality of the Nation's Milk Supply," July, 1943, and is set out in the Milk (Special Designations) Order, 1943. It is suggested in the circular accompanying this Order that the Regulations, as altered, give effect to the proposals for a *more satisfactory* veterinary examination, a statement which will be received with reservations by public health officials.

It is emphasised that a careful check upon the tests performed should be kept, while all records and reports should be maintained in proper order. Reactors must immediately be removed from the herd, but no definite indication is given as to the manner in which their disposal is to be undertaken. Indeed, many producers sell their reactors in the open market, while others maintain a separate herd composed largely of reactors from their Tuberculin Tested herds. Many animals are retained in this manner until disease symptoms become clinically recognisable. The undesirable features of either practice will be readily appreciated.

No animal may be added to an Accredited herd which has, to the owner's knowledge, reacted to the tuberculin test, although the owner is permitted to retain a cow in his herd which has been tested and reacted while "in the herd." It has been stated that the purpose of this concession is to encourage the transition from an Accredited to a Tuberculin Tested herd, so that reactors can be gradually eliminated. The idea is theoretically sound, but practically, due to the high value of animals at the present time, it has not attained its object. From a public health point of view there is no doubt that this privilege must be considered a retrograde step.

Apart from the tuberculin test, clinical examinations of cattle producing raw designated milks are carried out to determine the presence or otherwise of any of the following pathological conditions :

(*a*) Acute mastitis.
(*b*) Actinomycosis of the udder.
(*c*) Suppuration of the udder.
(*d*) Any infection of the udder or teats.
(*e*) Any comatose condition.
(*f*) Any septic condition of the uterus.
(*g*) Anthrax.
(*h*) Foot and mouth disease.
(*i*) Abscess of the udder.
(*j*) Any induration of the udder likely to affect the milk.
(*k*) Retained placenta.
(*l*) Any acute septicæmic condition.
(*m*) Enlargement of supra-mammary lymphatic glands.
(*n*) Tuberculosis of the udder.
(*o*) Tuberculosis of any form clinically recognisable.
(*p*) Chronic cough with definite tubercular symptoms.

Particulars attaching to the Attested Herd Scheme with some comments thereon will be found on pages 443 to 446, while the method employed in carrying out the tuberculin test is set out on pages 62 to 63.

The laboratory tests formerly applied to designated milks have been radically altered. The plate count for samples of such milks is no longer recognised, the methylene-blue reduction test having been substituted in its place. The usual coliform examination must be made, both tests being carried out in accordance with instructions set out in Memo. 139/Foods of January, 1937. A full description of the methods of sampling and of the testing technique employed will be found in Chapter X. When two tests are applied to any one sample, both tests must be complied with. The Ministry of Health states that it is not necessary for every sample to be subjected to both tests as, if frequent samples are taken, the majority may be examined by means of the methylene-blue reduction test alone. This recommendation is generally ignored in practice. Phosphatase and methylene-blue tests are prescribed for Tuberculin Tested (Pasteurised) and for Pasteurised milks, but no mention is made regarding the use of the coliform test for such milk. This is a serious omission as such an examination affords one of the best means available of ascertaining the efficiency of the pasteurisation process and the cleanliness of containers. The Heat-treated Milk (Prescribed Tests) Order, 1944 and the Milk (Special Designations) Regulations, 1946, set out the method of applying the methylene-blue and phosphatase tests to heat treated milks. A description of these methods will be found on pages 382 and 408.

It is also suggested that a licence should not be revoked following an occasional lapse from the standard laid down. The responsible authorities are advised that, in addition to obtaining samples for examination prior to bottling, it is advisable that samples should be taken in course of delivery to the consumer. The schedule of sampling suggested is twelve per annum. This suggestion is almost impossible of attainment and has remained largely inoperative, quarterly samples being usually obtained.

The methods of pasteurisation and the licensing conditions are dealt with in detail in the following Chapter and it is only necessary here to mention the two grades of milk treated by heat as specified in the Order of 1936. These are :

(1) Tuberculin Tested (Pasteurised).
(2) Pasteurised.

All pasteurising plants should be surveyed and tested by the licensing authorities before any licence is issued. The Minister of Health makes a recommendation to this effect, while it is emphasised that frequent inspections should be carried out in order to ensure that the methods adopted are continuously satisfactory. It is pointed out that, in addition to much improper heat treatment, a considerable quantity of milk is sold as " Pasteurised " during winter months which has not received such treatment. The phosphatase test which is now compulsory enables deficiencies in the pasteurising process to be detected. This test is described in detail on pages 408 to 413.

Fees

The fees payable for the various types of licences are set out below :

FOR A LICENCE AUTHORISING THE USE OF THE SPECIAL DESIGNATION " TUBERCULIN TESTED " OR " ACCREDITED "

	£	s.	d
Licence in respect of an establishment at which the milk is produced but not bottled	1	1	0
Licence in respect of an establishment at which the milk is produced and bottled	2	2	0
Licence in respect of an establishment (not being the establishment at which the milk is produced) at which the milk is bottled . .	2	2	0
Licence in respect of each shop or other establishment (not being the establishment at which the milk is produced or bottled) at or from which the milk is sold	0	5	0
Supplementary Licence with respect to milk sold from a shop or other Establishment which is outside the area of the licensing authority .	0	2	0

FOR A LICENCE AUTHORISING THE USE OF THE SPECIAL DESIGNATION "PASTEURISED"

	£	s.	d.
Licence in respect of the establishment in which the process of pasteurising is carried on and of any shop or other establishment in the area of the same licensing authority at or from which the milk is sold by the same dealer	1	1	0
Licence in respect of each shop or other establishment (not being an establishment covered by a licence under the last preceding item) at or from which the milk is sold	0	5	0
Supplementary Licence in relation to milk sold from a shop or other establishment which is outside the area of the licensing authority	0	2	0

The payment of a licence fee by persons producing a high-grade milk constitutes an anomaly which has caused much outspoken criticism among producers of graded milks. Licensing authorities are now given the above-mentioned scale of maximum fees but they may, if they so desire, charge less than the suggested scale or may even abolish fees in their entirety. Uniformity in this matter is urgently required. This would appear to be a question which the various Associations of interested local authorities might profitably consider.

Administration

The responsibility for administering the Orders of 1936–1946 as regards raw designated milk was placed upon the County or County Borough Council as the case may be, on whom the onus of control is placed. This has been used as an excuse on the part of many county officials for ignoring officers of the District Councils in working the Orders. As previously mentioned the control of raw designated milk production is to devolve eventually on the Minister of Agriculture and Fisheries.

A producer who wishes to obtain a licence to produce such milk must apply to the authority concerned. Following receipt of the application, the premises should be visited by an official of the licensing authority. There has, in the past, been little uniformity as regards the official delegated to make this inspection. Medical Officers of Health, Veterinary Officers, County Sanitary Inspectors, local Sanitary Inspectors, Agricultural Officers, Dairy Instructresses, Milk Officers, and Weights and Measures Inspectors have all been allocated the task, with a consequent lack of uniformity between County and County. Whoever carries out the inspection, it is essential that the local Sanitary Inspector should be consulted. Co-operation between County and local staffs should have been regarded as a prime essential. Many cases have occurred where County officers have drafted specifications of alterations and granted licences without any notification being sent to the local authority. Such actions have naturally caused resentment although, on the other hand, there do exist many local inspectors who have shown no interest in the work and who make no attempt to co-operate with the county staffs. It cannot be too often emphasised that close co-operation between all interested parties is essential. It should also be remembered that the only person who can legally insist on structural alterations to dairy premises is the local sanitary inspector ; on the other hand, if the requirements of the licensing authority were not complied with no licence would be granted If the licensing authority considers that premises or methods are such as will render the applicant unable to comply with the requirements of the Orders, a licence should be refused. The grounds for any such refusal should always be communicated to the applicant, who may then exercise his right of appeal to the Ministry.

At least four samples per annum from each producer should be collected and examined, with additional samples from those producers who fail to attain the specified standard. Each adverse report should be notified to the producer concerned and to the local authority in whose area the premises are situated. This report may be issued on a stock form. A visit to the premises should follow, in order that the producer may once again be placed on the path of clean milk production. Two or more failures to comply with the standard laid down indicate that the conditions on which the licences were granted are not being maintained in which case a plunger sample should be taken as a final test. In many cases it may be found that the producer is desirous of carrying out the correct procedure, but possesses imperfect knowledge. A further visit of investigation will often put matters right. Visits of inspection should always be made at milking time, in order to correct faults as they arise. It should again be emphasised that continued failure to comply with the specified conditions must result in the cancellation of the producer's licence, but any notification of cancellation should always contain a note to the effect that right of appeal to the Minister is allowed if made within seven days from the receipt of such notice. Many milk producers have obtained licences for the production of designated milk solely on account of the bonuses now offered for its production. Quite a number of these persons possess only an elementary knowledge of clean milk production methods, and are chiefly concerned with the financial benefit which will accrue. When taken to task their excuses are varied but seldom tenable, and although motives find no place in milk legislation, the existence of this type of producer is not without its drawbacks.

Handling of Graded Milks

The methods of handling milk have been dealt with in previous chapters. The routine there laid down will be satisfactory in the case of designated milks, always provided that strict care is taken to ensure that such methods are consistently carried out. As graded milk is produced under licence, certain precautions assume particular importance.

It is essential that any producer of such milk should be of cleanly and systematic disposition. He must personally, or through a capable person, supervise the work each day, in order to detect and remedy any errors that may be committed by his workers. If such precautions are neglected, the bacterial content of the product will be high, with consequent failure to comply with the requirements laid down.

Even in an up-to-date building, it is impossible to produce designated milk if the *methods* employed are unsatisfactory. Score-card inspections should be carried out before and after a licence is granted, and separate marks allowed for each item. This procedure will allow the inspector to indicate the improvements required. A copy of a standard-type score-card is set out in Appendix III, at the conclusion of this volume. It should be emphasised that it is impossible to produce consistently any graded milk without the assistance of suitable *steam sterilisation*.

The *closure and labelling of bottles* used to contain designated milks is important. Bottles must be sealed by means of both a disc and a cap unless a tight-fitting cap, which overlaps the neck of the bottle and which is approved by the licensing authority, is used. This overcomes any objections to the employment of aluminium caps and crown corks, and also permits the use of suitable containers of the "carton" type. It is essential that the type of seal should be such as will prevent any tampering with the milk after the bottle has been sealed.

The latest requirements covering the labelling of Tuberculin Tested and Accredited milks have been drawn up in much wider terms than was formerly the case.

Several types of seals have been described in the previous chapter (see Figs. 121 to 123), but aluminium caps or crown corks are now generally employed for sealing bottles of designated milk and are ideal for this purpose. Such caps have now been approved by the Minister of Health. The aluminium-foil, paper-lined cap as shown in Fig. 146 possesses many advantages. By its efficiency and cheapness, it should appeal not only to producers and distributors of all graded milks, but also to milk retailers as a whole. The advantages claimed for this type of cap are :

(1) It is simple and economical.

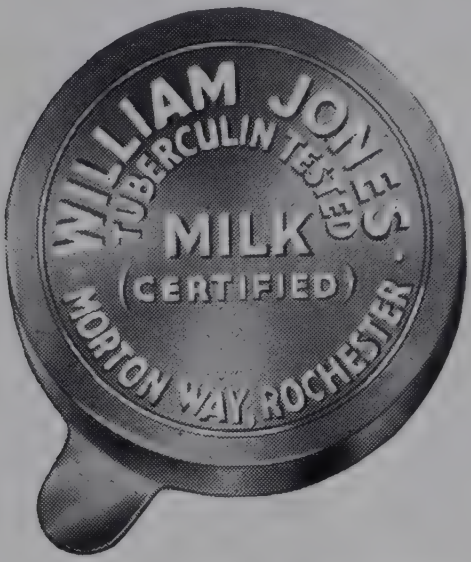
(2) It is a definite aid to pure, uncontaminiated milk, as it protects the vital portion of the bottle, i.e. the lip.

(3) It cannot be removed and replaced wtihout detection, while it is germ-proof, air-tight and non-absorbent.

(4) Such caps may be quickly affixed, either by hand or machine.

(5) The advantages of milk capped in this way are obvious to and appreciated by the consumer.

The "Autolex" cap (Fig. 123), is a further example of this type of closure. The crown cork has already been considered on page 211.



By courtesy of Clare's Service.

FIG. 146. Aluminium Bottle Cap for Designated Milk.

Analysis has often shown that samples of designated milks bottled at the farm are deficient in milk fat or solids-not-fat, while at other times the milk may possess a high butter-fat content. This is due to the bottling of milk from one or two cows direct from the cooler, in order to prevent bacteriological contamination from external sources. As already stated, milk from individual cows in the same herd may vary greatly in composition, so that at any given time some cows may be yielding poor quality milk while others may be giving milk which possesses a fat content considerably above the average. The normal custom is to mix milk from the various animals before it is bottled. This ensures that the consumer obtains an average product. The stress laid on the necessity for preventing bacterial contamination has led to the development of the above-mentioned practice which, while assisting cleanliness, has objections from the standpoint of nutritional value and is thus to be deprecated.

Faults in the Present System of Grading

Although the Milk (Special Designations) Order, 1936 constituted a step in the right direction, it cannot by any stretch of imagination be considered final or ideal. There can be little doubt that the confusion which still arises over the new designations has equalled that which has confronted the trade and public health officials, to say nothing of the consuming public, since the inception of the Order of 1923, an unfortunate confusion which it was fondly hoped this Order of 1936 would finally abolish. The intention of this Order was to simplify the designations of milk produced under specified conditions, thus fostering the production of *safe* milk, An unbiassed review of the system at present in operation reveals the fact that the principle of grading is still far from satisfactory. Retailers of other foodstuffs are not allowed to market unsound or diseased food, while articles of food sold in this country are either fit for human consumption or they are not, there being no half-way house. It is only right, therefore, that the public should expect milk when purchased to be both good in quality and *safe*. The present grading system does not satisfy these requirements, although it must be admitted that the introduction of graded milks has done much to improve the supplies of other raw milks sold to the public.

There can be little doubt that, considering the vital importance of milk, such designations as are employed at the moment are confusing to the purchaser. They are also misleading, as they in no way denote the true quality of the milks so designated. In buying most articles of food the purchaser is able to determine whether or not he is obtaining value for money. Milk, however, cannot be purchased in this manner, since it may vary in chemical composition and hygienic quality without any change in appearance. The only way in which the purchaser can readily estimate the relative values of designated milks is by some proper means of classification, which classification should supply a true indication of the value of the product. The fact that this indication is absent is a serious defect in the present system which calls for immediate remedy.

Although producers and retailers of ordinary raw milk are prohibited from attaching designations such as " A1 " and " Tested milk " to their product when it has not been produced under licence, a great deal of advertising of ordinary raw milk as being produced " from tuberculin-tested cows " has been carried out in the past. Such captions have often been falsely used and have further confused the consuming public, even when such a statement has been true. Until 1934 this was not an offence against Section 3 of the Milk and Dairies (Amendment) Act, 1922, then in force, although purchasers of such milk were no doubt often misled into buying this milk in the belief that they were obtaining an article of graded quality. Under Section 10 of the Milk Act, 1934, subsequently repealed by Section 21 of the Food and Drugs Act, 1938, the employment of such designations is illegal, and the use of any phrases likely to imply that the milk is a designated article is prohibited unless that milk has in fact been obtained from cows which have passed the tuberculin test.

An outstanding fault of the Order and one which has a direct bearing on the quantity of such milk bought by the public, is the fact that producers of designated milks have to carry on their business under the financial handicap of licence fees, while producers of ordinary raw milk, which may be and very often is of doubtful quality, incur no such expenditure. It should be stated, however, that following the recommendations of the Minister of Health, quite a number of licensing authorities have made a reduction in the licence fees demanded from producers and distributors. The producers of designated milks are also required to bear considerable expense in having their herds tested by the tuberculin test, and of frequent veterinary inspections The ordinary producer has his animals examined free of charge after, be it remembered, it has been proved that his milk is a danger to the public health !

In the case of a producer of designated milk, a reactor must at once be removed from the herd, and if sold such an animal is generally disposed of at a loss. The milk produced must also conform to certain standards, any continued omission on the producer's part being likely to lose him his licence. Added to this is the expense which he primarily incurs in freeing his herd from reactors before he can commence production.

Up to the outbreak of the present war, the demand for designated milks was not widespread owing to their higher cost. The gap in price which existed between ordinary and designated milks has now been reduced, the Minister of Food having fixed a maximum price of 5*d*. per pint, the producers' extra costs being met by subsidies. Even this all-round reduction in retail price has not boosted the sales of designated milks to any great extent, as the public has, in many instances, only the vaguest knowledge of the enhanced value to be obtained. Indeed, a large quantity of subsidised designated milk is bulked with ordinary raw milk at collecting depots in various parts of the country, a procedure which is to be deprecated as a waste of time and energy on the part of producers of such milk and a serious waste of the taxpayers' money.

In the case of Tuberculin Tested milk which is obtained from animals presumably free from disease, a real necessity is the provision of a more frequent tuberculin test, the intervals between such tests at present being too great. Roodhouse Gloyne, in the examination of fifty-two samples of milk from tuberculin tested herds, found two samples positive, i.e. 3·8 per cent. of the number examined. Sir George Newman, when Chief Medical Officer to the Ministry of Health, stated in his Annual Report for 1931 that, among the samples of milk taken from 441 farms under licence for the production of milk from tuberculin-tested cattle, eight gave positive results. This evidence shows that the present bi-annual test is insufficient, since, in the case of animals yielding milk containing tubercle bacilli, the disease must have reached the udder in the great majority of cases. If a more frequent test had been applied, it is probable that the affected cows would have been detected at an early date, before the disease had become so far advanced as to affect the milk supply.

It is also extremely unfortunate that Tuberculin Tested milk, incorporating as it does the former "Certified" grade, is permitted a similar methylene-blue reduction standard to that of Accredited milk. This appears to be a definitely retrograde step in that the permitted standard has been appreciably lowered. Those producers who spent years of thought, trouble and expense in raising the standard of their herds and their methods of production, have generally relaxed their efforts and are offered no inducement to continue their former policy of highest grade production. While the Order of 1936 has no doubt raised the general standard of milk supplies throughout the country, the maximum of efficiency formerly attained in many instances has been materially reduced. This, in turn, has had unfortunate repercussions upon the industry as a whole.

Yet another vital weakness exists in the present Order. If a reacting cow is in full milk there is nothing to prevent a producer who sells ordinary milk in addition to his graded product from adding such an animal to his general herd. This practice is unfortunately quite common, is totally wrong, and should not be tolerated.

In innumerable cases reactors are sold in the open market, the purchasers often being unwittingly saddled with a tubercular animal. Reactors sent to be auctioned should be branded, so that the ordinary buyer may identify them.

The present grade of Accredited milk is not a product of tuberculin-tested cattle, since only a clinical examination of the herd is necessary. The results of such clinical examinations are not in every case satisfactory, many cases of tuberculosis being difficult to detect until an animal is in an advanced stage of the disease. Such an examination cannot therefore supply any guarantee of freedom from tuberculosis or freedom from infection of the milk. Indeed, figures given by Savage in 1944 appear to prove that Accredited milk is even more contaminated with tubercle bacilli than ordinary raw milk although it must be emphasised that such figures are not complete. In many instances, animals causing such an infection of the milk supply are not discovered, even when examined by a competent veterinary surgeon, until the milk from each animal has been tested separately. On the ground of the absence of any guarantee of safety, Accredited milk cannot be said to be satisfactory ; indeed, large quantities of milk of equal hygienic quality are produced in this country daily and are sold as ordinary milk. In spite of this fact, Accredited milk is sold under official guarantee, although, as previously mentioned, its safety cannot be warranted. This privilege is not equitable to those producing the highest grade of milk, especially as, with a name such as it bears, and taking into consideration its lower cost, its sale may be more readily assisted to the detriment of the better grade.

The term " Accredited " might quite readily be interpreted and indeed is, as implying that the product so labelled is of a satisfactory standard both as regards cleanliness and *safety*. Yet this is far from being the case. If Accredited milk were entirely safe, there would be no need for a higher grade such as Tuberculin Tested ; while alternatively, if the conditions demanded for Tuberculin Tested milk are necessary to ensure safety, those applying to the Accredited grade are obviously insufficient to achieve this object. As indicated on page 444, milk supplied as food to attested herds must either be produced from tuberculin-tested cows or *be pasteurised or sterilised by heat*. If these conditions are necessary to protect animals from tuberculosis, it is obvious that a lower standard of protection cannot be justifiably offered to human beings. As this is all that Accredited milk has to offer, it cannot be confidently accepted as a safe milk. It might be argued that the compulsory production of a *safe*, one-grade milk (apart from the pasteurised article) is an economic impossibility, but in specifying the designations steps might have been taken to prepare the way for the *only* method by which the public of this country can be assured of a truly safe product. In other words, so long as milk-borne bovine tuberculosis infection is possible, so long will the standard of the milk supply fall short of what it can and should be.

The Future of Designated Milks

Few persons will deny that the present grading system has been useful, inasmuch as it has been the means of providing a superior quality of milk for those prepared to pay the higher price demanded. There can be no doubt that designated milks supply a definite need and are to be encouraged, not only for their educational value but also because of the increased food value of such milk, always provided that it is classified in a manner which allows of a ready understanding. This, however, is not sufficient, especially as the production of a clean, non-pathogenic milk is voluntary and not compulsory, as should be the case. The advantages of a grading system which can be readily understood by the consuming public would no doubt be the means of increasing the sale of such milk, and would therefore induce many more producers to attempt the production of one or more of the designated products. From this viewpoint alone it is essential that some clearly understood grading system should be provided. In the case of raw milk, with the exception of those of the Accredited and Tuberculin Tested varieties, the producer at present receives the same price, whether his product be clean or dirty. The greatest difficulty confronting the producer of Tuberculin Tested milk is to be able to convince the public that his milk is the best. As already indicated, the array of permissible designations allowed under licence do not convey to the consumer the true meaning concerning the relative merits of the various grades.

There will be almost general agreement with the following points :

(1) Pure, non-pathogenic raw milk is always preferable to milk treated by any heating process, *provided its purity and safety can be guaranteed.*

(2) Milk consumed raw should be free from any pathogenic organisms.

(3) There is, at present, only one method which affords any guarantee that an animal is free from tuberculosis—the tuberculin test—which is only compulsory for one grade of milk.

(4) Cows which react to such a test are potential sources of infection to the milk, owing to the rapidity with which the disease progresses, although they may not be yielding tuberculous milk when tested.

(5) Pasteurisation is the only means of ensuring the safety of milk through the destruction of any pathogenic organisms which it may contain, without material alteration of food value.

The grades of " Certified " and " Grade A (Tuberculin Tested) " have been amalgamated by the Order of 1936 to form one grade—" Tuberculin Tested." This is considered one means of simplifying the confusion which once existed in the minds of the general public. This alteration has, of course, somewhat simplified matters, but it has also resulted in lowering the standard of the combined grade. When milk is bottled by the distributor, it is not possible for the product to reach the standard of bacteriological purity which, in raw milk, can only be attained by bottling at the farm. The production of graded milk of the high standard once obtainable has to a large extent ceased, especially when it was found that the new grade of milk when bottled by the distributor was capable of attaining the standard required. Other serious difficulties have also arisen. The cost of bottling the new grade at the farm and increasing costs of transport by rail in bottles have rendered the costs of production and distribution so high, even with the present subsidy of 4*d*. per gallon and the controlled retail price of 5*d*. per pint, that few distributors have been able to sell such milk under its proper designation. Large quantities purchased from the producer have been and are continually being bulked with ordinary supplies and pasteurised before delivery. In combining the two grades it has been necessary to lower the standard of the combined grade to allow those producers of the former " Grade A (Tuberculin Tested) " milk to compete with those who formerly produced " Certified " milk. If this had not been done, these producers would have been quickly eliminated. In short, the disadvantages of amalgamating the two grades have been :

(1) The highest grade of milk ever produced in this country has been abolished. As it is the aim of all public health officials to raise and not lower the standard of milk supplies, this must be considered a retrograde step.

(2) Many if not most of the producers of the former "Certified" grade of milk have received so much discouragement on account of the time and effort already expended that they have probably ceased production of milk having a bacterial content as low as formerly.

The basis of classification at present employed in this country for raw designated milks is in accordance with their hygienic quality and is :

(1) Whether or not the milk is produced by herds free from reactors to the tuberculin test.
(2) The methylene-blue reduction test.
(3) The presence or absence of *Bacillus coli*.

There can be no doubt that the hygienic quality of the milk is most important. This quality should form the basis for any standards which may be enforced in future years. The wholesomeness of the milk supplied depends upon the number and kind of bacteria which it may contain, and it is of the greatest importance that milk should not contain any pathogenic bacteria of which tubercle bacilli are the most vital. The question as to whether or not the milk should be required to have a low *Bacillus coli* content also requires consideration. It is usual to find such organisms present in excess when the total bacterial content of the milk is high, the converse being also the case. The table below shows the results of bacteriological examinations of some samples taken by one of the writers, and illustrates this point :

TABLE 14

High Counts.			Low Counts.		
Sample No.	Total Bacterial Count.	*B. Coli* Present in ml.	Sample No.	Total Bacterial Count.	*B. Coli* Present in ml.
1	400,000	0·00001	1	1,100	Negative
2	500,000	0·0001	2	4,600	Negative
3	800,000	0·00001	3	8,700	Negative
4	1,600,000	0·00001	4	5,100	1·0
5	500,000	0·00001	5	6,150	1·0
6	520,000	0·0001	6	4,750	0·1
7	500,000	0·00001	7	3,000	0·1
8	380,000	0·0001	8	2,570	1·0

The estimation of the presence of coliform bacilli is useful as an indication of manurial pollution and of unsatisfactory methods, yet it is not essential that this estimation should be carried out since, by the use of cleanly methods, both *Bacillus coli* and other harmful organisms should be entirely eliminated.

In milk of any kind the essential food value is dependent upon the chemical constituents, of which butter-fat is the most valuable. Some public health authorities have suggested that with any alteration, a standard for butter-fat should have been fixed for all designated milks. Although there is much to be said for this suggestion, the operation of such a scheme would be exceedingly difficult if not impossible. To maintain a uniform standard it would be necessary to mix large quantities of milk either before or after cooling, with a consequent delay in placing the bulked milk into sealed receptacles and with increased danger of pollution after production. It is possible to equalise the butter-fat content of milk in the receiving tanks of large dairies, and this is often carried out. On the farm this would be an extremely difficult task owing to the variations in butter-fat content between morning's and evening's milk and between one cow and another, together with seasonal variations.

Although it is true to say that simplification is still necessary in order to attract public attention to the value of designated milks, it is equally essential that sufficient grades of milk should be available to the public. Care must therefore be taken to ensure that any grades which are necessary for the proper and continuous advance in the methods of producers and distributors should be provided, with a view to the constant improvement of the nation's milk supply. The classification of milk is primarily a public health measure, and it is necessary that the public should be catered for in a simple but thorough manner, since upon public goodwill depends the future of the milk industry.

The designations should be such as will instantly convey to the consumer the relative quality of the grades. The words "Tuberculin Tested" do not provide the consumer with any sufficient knowledge of the value of such milk. Again, it must be emphasised that "Accredited" milk, which the public often believes is of the highest quality, has not even the advantage of being produced from tuberculin-tested cattle. Because a certain safety in production and handling is guaranteed, this is surely no reason why any milk should possess such a designation as "Accredited." The term "Pasteurised" aptly described the article in question, but the use of the title "Tuberculin Tested (Pasteurised)" not only throws doubt in the minds of customers as to the value of Tuberculin Tested milk, but also gives them the impression that there is some risk in connection with the article. Otherwise, why the need for pasteurisation? The terms "Tuberculin Tested (Pasteurised)" and "Accredited" should therefore be abolished, especially when the numbers of consumers who may purchase such milk under the impression that it is a safe article are considered.

In the writers' opinion, the following designations, if applied to raw milk, would do much to banish the present misconceptions of the grading scheme:

(1) *Grade* 1. Raw milk from tuberculin-tested and clinically examined cows, such test and examination to be carried out every three months. The milk to be bottled at the farm and have a minimum reduction time during summer and winter, at any time prior to delivery to the consumer, of not less than eight hours.

(2) *Grade* 2. The present conditions under which "Tuberculin Tested" milk is produced to hold, except that the minimum total reduction time, irrespective of season, at any time before delivery to the consumer, to be not less than five hours. In summer such milk could, if desired, be pasteurised.

In view of the discovery of tubercle bacilli in graded milks supposedly from tuberculin-tested cattle, it would appear essential that, in any scheme of re-grading the intervals between tuberculin tests must of necessity be shortened, while the cost of every test should be borne by the State. It must also be emphasised that a more rigid and more frequent clinical examination of the animals of any herd producing raw milk of a specified grade should be made, in order to prevent the pollution of such milk by organisms such as the *hæmolytic* (*mastitis*) *streptococcus* and the *Brucella abortus*. Such an improvement should be within range of practical application, but it should also be borne in mind that such frequent veterinary inspections would be considerably assisted by a much more frequent sampling of milk for both bacteriological and biological examinations. For this reason it is essential that such provision should be made in any new scheme.

It may be argued that, in providing for two grades of milk only, there would be no inducement for producers to spend their time and energy in producing a higher grade of milk when they could, with less trouble, produce an inferior article. It has also been stated that producers would not care to produce and retail milk of Grade 2 standard, particularly as the designation would reveal the fact that it was not of the highest quality. If this statement were true, then the reason why so many persons produce Accredited milk at present, apart from the monetary inducement afforded, is apparently that they hope their customers will be led to believe that the milk which they are producing is of the highest quality. There is also the price factor to be taken into consideration, there being no doubt that the higher price to be obtained for Grade 1 milk would give sufficient encouragement to farmers to put forth the requisite effort to produce the better article. The time is rapidly approaching when the compulsory classification of milk will have to be considered. Indeed, the Minister of Food already possesses powers to bring this into being in areas to be later specified and, although the grades likely to be standardised will not meet with universal approval, it is to be hoped that this first step towards such compulsory classification will lead to a straightforward course being adopted.

With regard to the designated milks which should be allowed to be treated by heat, the following suggestions are made :

The practice of pasteurisation has been and still is condemned by many producers, but it must be remembered that this process has proved itself one of the farmers' best friends. Without its aid, much of the milk at present produced could not be sold. Pasteurisation is a process which should be used to give complete safety to such raw milk as requires this safeguard. By far the greater quantity of milk produced in this country could not and does not at present come within the limits suggested for Grades 1 and 2, and would, under the proposed régime, be unfit for sale unless pasteurised before delivery. This does not mean that pasteurised milk is of necessity inferior milk. Dirty milk may be heat-treated just as dirty milk may be sold raw, but the practice is decreasing and should not be allowed to militate against the process. The producer who is careless in his methods should not rely upon any form of heat-treatment to make his dirty milk wholesome. The remedy for lack of care upon the part of producers does not lie in the entire suppression of heat-treatment, but in the continuous education of the producer with a view to his practising more satisfactory methods. Such an education, for those requiring it, can be more quickly and best completed by a compulsory classification of all milks on the lines already suggested for raw milks and to be suggested for pasteurised milks. It is the careless methods of the farmer which have led the opponents of pasteurisation to assert that the process is only used as a means of covering up careless production methods.

It would be necessary to pasteurise all raw milk outside Grades 1 and 2 as a means of rendering such milk entirely safe. This would be particularly valuable in view of the incidence of tuberculosis among dairy cattle. Whatever may be the effect of such treatment on the food value of milk, an effect which is usually exaggerated, it is preferable that the public should, if they could not afford or obtain milk of Grades 1 or 2, be able to purchase a milk which has, by means of pasteurisation, been rendered safe from the *Bacillus tuberculosis* and other pathogenic organisms. The fact that cattle which would be producing milk of Grades 1 and 2 are tuberculin-tested and clinically examined at short intervals, together with the fact that such milk would be produced under scrupulously clean conditions, would ensure that such raw milk as was sold could rarely, if ever, be the cause of any milk-borne outbreaks.

It would be unwise to provide that Grade 2 should not be treated by pasteurisation, for the following reasons:

(1) It has frequently been found impossible for Tuberculin Tested milk to be delivered to the consumer during the summer months in a sweet condition. Grade 2 milk, therefore, which would have to attain a higher standard during summer than the present Tuberculin Tested milk, would be more difficult to keep with the necessary limits specified. For this reason alone it should be treated by pasteurisation.

(2) Many large distributors wish to supply their customers with a high-grade pasteurised milk. If the pasteurisation of Grade 2 milk were allowed, there would be an increased sale of this milk to reputable pasteurising firms.

(3) Many consumers prefer pasteurised milk to raw milk, as they have become accustomed to such milk; while a large proportion would prefer to purchase a high-quality milk treated in this manner rather than a poorer quality of pasteurised milk.

There would be no need to pasteurise Grade 1 milk, for the following reasons:

(1) It would be bottled at the point of production. There would thus be no risk of any subsequent contamination, as in the case of Grade 2 milk.

(2) As it would have to be bottled immediately after production, such milk would, if pasteurised, required to be treated at the farm and would thus have to be pasteurised in bottles. The cost of providing pasteurising plant at the producer's premises would be prohibitive.

(3) The liberty allowed to distributors in the pasteurisation of Grade 2 milk would satisfy the demand for a high-quality pasteurised milk.

The following are the suggested standards to be enforced for designated and other milks treated by heat:

(1) *Grade 2 (Pasteurised).* This milk should have a minimum reduction time of one hour, and coliform organisms should be absent in 10 millilitres of the milk, at any time before delivery to the consumer.

(2) *Standard Pasteurised.* This grade covers all raw milks other than Grade 1, which need not be pasteurised, and Grade 2 which is dealt with above. The reduction period should be similar to that now laid down for pasteurised milk, and coliform organisms should be absent in 10 millilitres of the milk at any time before delivery to the consumer.

In the case of both grades, absolute compliance with the compulsory phosphatase and methylene-blue tests should be required, such testing to be carried out at weekly intervals. It is equally essential that an examination should be made of all samples for the presence of coliform organisms, as a means of ascertaining the efficiency of the process and subsequent handling.

Finally, producers of designated milks should not be penalised by having to pay licence or veterinary surgeons' fees. The production of designated milks under the scheme as outlined should be encouraged, and all restrictions in the paths of the producer and distributor swept aside. Control can and should be effected without the imposition of fees, while no producer should be prohibited from supplying a high-quality milk because of veterinary fees. All pasteurisation should, of course, be efficiently controlled, with adequate inspection by officials of the local authority.

Many countries have made the grading of all milk compulsory. In Italy, for example, great strides had been made before the outbreak of the present war in the protection of the consumer from the dangers of infected and dirty milk. Only two grades of milk were allowed to be sold to the public. These were " Certified " milk, which had to attain a standard comparable to that in force when milk was sold under a similar designation in this country ; and " Pasteurised " milk, which included all milk other than that graded as " Certified." Pasteurisation was carried out by the low-temperature holding system.

The scheme appears to be sound, and it is to be hoped that a grading system on comparable lines will eventually be adopted in this country. Steps to attain this end have already been taken by the Minister of Food, who has, under Regulation 55G, of the Defence (General) Regulations, 1939, received power to make Orders to ensure that all milk to be sold in certain areas to be later specified shall either be " Tuberculin Tested," " Accredited," " Pasteurised " or " Sterilised " milk. This is definitely a great move forward towards the attainment of a satisfactory milk supply, although it would have been more satisfactory if " Accredited " milk had not been included.

CHAPTER IX

THE TREATMENT OF MILK BY HEAT

A LARGE proportion of milk produced in this country is treated by heat in one of a variety of ways. It will be found on inquiry that opinions as to the heating of milk vary according to the individual whose views are sought. It is the present consensus of the highest medical opinion that such treatment, if efficiently carried out, provides a desirable and necessary safeguard, applicable at relatively small cost and without, in most cases, materially affecting the food value of the product; therefore, if such opinion were sought, the answer would usually be that some form of treatment by heat was essential to render the milk supply safe. The large dairy companies would also no doubt agree with the expressed opinion of the medical profession. The majority of farmers, on the other hand, appear to be against pasteurisation or other form of heat treatment, arguing that this process is detrimental to the health of the consumer, inasmuch as the food value of milk is impaired by heating to any degree of temperature. It is probably obvious to all concerned with milk production that, without some form of treatment by heat, much milk produced annually in this country could not be sold, especially when the long distances of transit are considered. In such cases, if no heat treatment in some form or another were applied, a great quantity of milk would be sour before delivery to the consumer.

The Effect of Heat on Milk

Milk undergoes certain alterations when heated, and these changes are influenced by two factors, as follows:

(1) Time during which milk is exposed to the heating agent.
(2) Temperature reached during the process.

Milk, in a similar manner to other liquids, expands on heating, the co-efficient of expansion being greater than that of water. The following changes also occur:

(1) The product loses its viscosity.

(2) A pellicle or skin commences to form on the surface of milk heated in contact with air at a temperature between 140° F. and 158° F. and complete formation occurs when boiling-point is reached. This pellicle has been found to contain a proportion of all the constituents in milk, but principally lacto-albumin. Formation does not occur when milk is heated in a closed vessel.

(3) Carbon dioxide is driven off, and the bi-carbonates are partially decomposed causing slight decrease in acidity while the constituent calcium and magnesium salts are precipitated.

(4) Milk which has been heated to a temperature of 165° F. for thirty minutes will not coagulate with rennet. If heated to temperatures between 105° F. and 165° F., coagulation will occur, although such action will be retarded. The failure of heated milk to coagulate is due to the precipitation of calcium salts which renders the casein in milk less easily coagulable. The addition of lime to heated milk will hasten the process of coagulation.

(5) Lecithin and nuclein are decomposed.

(6) Above a temperature of 145° F. fat globules are disturbed, so that the cream-line begins to be affected, but heat does not appear to have any effect on the composition of milk-fat.

(7) Enzymes are destroyed if milk is held at a temperature of 175° F. for a short period.

(8) At temperatures above 145° F. the percentage of diffusible calcium is reduced.

(9) When the temperature of milk is raised to 150° F., the albumin begins to coagulate, increased coagulation being observed as the temperature is increased.

(10) The heating of milk produces a taste which is particularly noticeable to those possessing sensitive palates. This taste varies according to the temperature attained during the heating process. The excessive temperatures attained during the sterilisation of milk produces a " burnt " taste, due to the burning of lactose. This is known as " caramelisation," the milk becoming pale brown in colour.

(11) At a temperature of 145° F., the freezing-point of milk is slightly raised and acidity slightly reduced.

(12) The prolonged heating of milk to 145° F. or over, destroys any bacteria which may be contained, according to the period of heating and temperature attained. The toxins of such bacteria are destroyed at relatively low temperatures. After boiling, the remaining bacteria consist entirely of spore-forming organisms and certain varieties highly resistant to heat.

(13) Phosphates are precipitated by prolonged heating at high temperatures, while such temperatures cause the destruction of vitamins C, B_1, A and D in that order.

(14) Milk which has been heated forms a finer coagulum or curd in the stomach than does raw milk.

Present Methods of Treating Milk by Heat

Milk may be treated by heat in the following ways :

(1) *Pasteurisation.* The most popular method of processing milk by heat. Several methods of treatment are employed of which the low-temperature method, pasteurisation-in-bottle and the high-temperature short-time process are the only ones legally recognised.

(2) *Sterilisation.* A process by which milk is heated sufficiently to destroy all bacteria which may be contained therein.

(3) *Homogenisation.* A certain proportion of milk is treated in this manner following pasteurisation and also prior to sterilisation. The aim of the treatment is to emulsify the fat globules in milk in order to ensure an equal cream content.

(4) *Stassanisation.* A Continental process which is at present in an experimental stage in this country, by which milk is heated to a high temperature for a short period. It is claimed to be an efficient substitute for pasteurisation.

Whichever process is chosen, careful attention must be given to the following points :

(*a*) How far is the process efficient in attaining its object ?

(*b*) Is the treatment by heat during processing detrimental to the food value of the milk ?

(*c*) Is the retail price of the product increased by such a process ?

PASTEURISATION

Volumes have already been written for and against this method of treatment, and the process will doubtless continue to evoke serious criticism or lavish praise from all interested in the milk industry for some considerable period. At the present time, it is impossible to guarantee the safety of milk as generally produced. One result has been to cause responsible authorities to strive by every possible means to obtain milk for liquid consumption as safe as humanly possible. This endeavour has resulted in a spate of legislation in order that the product should correspond more closely with scientific discovery and satisfy the essential requirements of public health. As a result, continued progress has been achieved in the production of milks treated by heat to give them complete safety, the process generally adopted for this purpose being pasteurisation.

Much of the confusion and criticism amongst the uninitiated is due to their lack of knowledge as to what pasteurisation really implies. Porcher has defined the process as follows :

> " Pasteurisation of milk should destroy, by the suitable employment of heat, practically the whole of the bacterial flora and the whole of the pathogenic flora, if any, whilst introducing the slightest possible alteration in the physical structure of the milk, or in its constitution, chemical equilibrium and bio-chemical elements (diastase and vitamins)."

Whether or not one agrees with such treatment, it is apparent that pasteurisation has come to stay. Particularly is this so when one remembers that the Minister of Food has power under Regulation 55G of the Defence (General) Regulations, 1939 (see page 435) to make orders specifying the grades of milk which may be sold in any particular district, pasteurised milk being one of these. In London alone approximately 95 per cent. of milk sold is now pasteurised before distribution, while in Manchester and Glasgow between 80 per cent. and 90 per cent. of milk receives some form of heat treatment.

This method of treating milk has a long history. Louis Pasteur, the great French scientist, first explained the benefits to be derived from the application of heat to certain foodstuffs, although the distinction for demonstrating the value of such method is credited to an Italian biologist, Lazzaro Spallanzani, who, in 1768, conserved food by means of heat. The employment of this method of food preservation was also investigated by the Swedish chemist, Wilhelm Scheele in 1783, while in 1795, Nicholas Appert, the inventor of canning, applied his process to milk. Although these scientists forestalled Pasteur in the application of heat as a means of food preservation, posterity owes to him the present process of pasteurisation. During the early part of his career he paid considerable attention to the problem of bacterial growth in milk. Between 1857 and 1862, he proved that milk became sour through the multiplication of organisms which he believed obtained entrance from the atmosphere. He demonstrated that heating milk would destroy many of the organisms which milk contained and would postpone souring. During the time when he was commencing his research work on milk, a milk product preserved by heat, was marketed in America. In 1856, Gail Borden obtained patent rights for a method of concentrating milk under vacuum, his work following on the lines of research undertaken by Pasteur.

In spite of the discoveries of Pasteur and Borden, twenty years elapsed before the value of heat as a means of safeguarding the milk supply was realised. The first commercial pasteuriser was manufactured in Germany during 1880, by Ashborn of Hildesheim, while about the same time, Fresca of Berlin, produced a similar plant. A few years later a Danish pasteuriser appeared, and, by 1885, milk was regularly pasteurised in Copenhagen and Stockholm. In 1886 the German chemist, Franz von Soxhlet, advanced matters a step further by advocating the sterilisation of milk for infant feeding. He stated that infants fed on such milk possessed a greater chance of survival and, far in advance of his time, he invented a method of sterilising milk in bottles. His methods were investigated by Caillé and Jacob in New York during the years 1888–89, who urged that similar methods should be employed in America. During the years which followed, pioneers had to struggle against prejudiced opponents of the process. Compared with other scientific developments, pasteurisation always appears to have offered ample material for controversy, so much so that the layman may well have given up hope of ascertaining the true position.

Milk pasteurised for sale under the terms of the Milk (Special Designations) Orders, must comply with the following conditions :

(1) *Tuberculin Tested* (*Pasteurised*). (*a*) Samples of milk must satisfy the phosphatase test by giving a reading of 2·3 Lovibond blue units or less and fail to decolourise methylene blue in 30 minutes at any time prior to delivery to the consumer.

(*b*) The bottle cap shall be labelled " Tuberculin Tested Milk (Pasteurised)."

(2) *Pasteurised.* (*a*) Samples of milk must attain a similar standard to that laid down for Tuberculin Tested (Pasteurised) Milk at any time prior to delivery to the consumer.

(*b*) The milk shall be labelled " Pasteurised."

(*c*) Milk shall be pasteurised by being retained at a temperature of not less than 145° F. and not more than 150° F. for at least half an hour, and shall then be immediately cooled to a temperature of not more than 55° F. This requirement has been amended by the Milk (Special Designations) Regulations, 1941, to allow the use of the High-temperature Short-time process, in which case milk shall be retained at a temperature of not less than 162° F. for at least 15 seconds and shall then be immediately cooled to a temperature of not more than 55° F.

(*d*) Milk shall not be heated more than once, or otherwise treated by heat in any way.

(*e*) The type of apparatus and methods employed shall be satisfactory to the Licensing Authority.

(*f*) After pasteurisation milk must not be placed in any apparatus or storage vessels which are used for milk which is not pasteurised.

(*g*) Such indicating and recording thermometers as the Licensing Authority consider necessary shall be inserted in suitable places in the apparatus used for pasteurisation during the whole process. With the High-temperature Short-time process the apparatus shall be thermostatically controlled and be provided with a device which shall automatically divert the flow of any milk which has not been retained at a temperature of not less than 162° F. for at least fifteen seconds.

(*h*) Temperature records shall be made and all such records shall be preserved for inspection for at least one month.

Methods of Pasteurisation

Although only two methods of pasteurisation are recognised by the Ministry of Health for the treatment of milk to be sold under the designations " Tuberculin Tested (Pasteurised) " and " Pasteurised," this method of processing is used by many dairymen in a variety of ways as a means of improving the keeping quality of milk which is not intended for sale within the terms of the Milk (Special Designations) Orders.

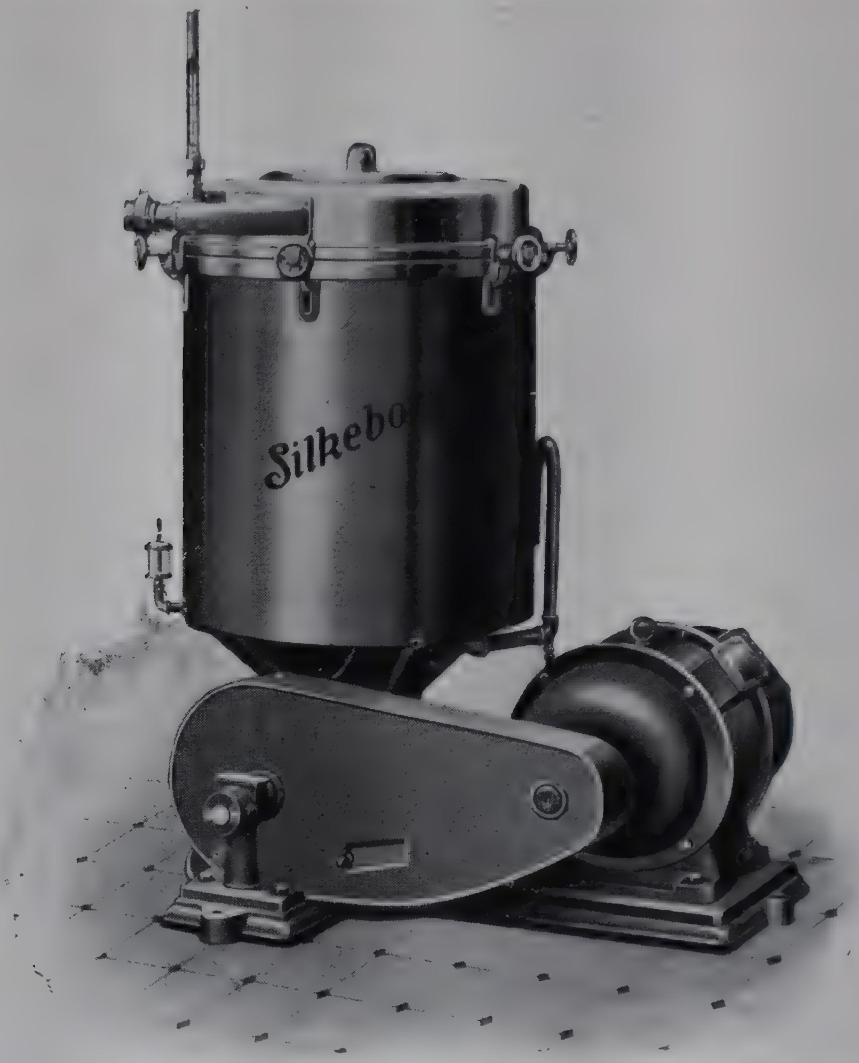
There are several methods by which milk may be treated, as follows :

(1) " Flash " Pasteurisation.
(2) " Continuous-flow " Method.
(3) Low-temperature " Holder " Process, which may be subdivided into :
    (*a*) " Batch " Pasteurisation for the small distributor.
    (*b*) " Multiple Compartment " Method for the large operator.
(4) Pasteurisation in Bottles.
(5) High-temperature Short-time Process.
(6) Vacuum Pasteurisation.

(1) **" Flash " Pasteurisation.** In this process milk is heated to a high temperature, generally in the neighbourhood of 160° to 170° F., or even higher, and then immediately cooled. " Flash " pasteurisation is similar to the " Continuous Flow " method, except that milk is not held for any period during its passage through the apparatus. In the usual type of " Flash "

pasteuriser, milk enters a hollow vertical cylinder at the lower end and, by means of a rotating device, is distributed by centrifugal force in a thin film over the inner surface of this cylinder, finally leaving at the upper end. The cylinder is surrounded by a combined steam and water jacket.

The "Flash" pasteurisers in use in this country are mostly of Continental manufacture, very few plants of this type being produced in Great Britain. This is probably due to the fact that this method of treatment is not recognised by the Minister of Health as a means of securing efficient pasteurisation of milk. Further, it is extremely doubtful if such apparatus could be employed for short-time processing on account of its many disadvantages. In view of the quantity of milk which can be handled by plants of this type, they appear comparatively small when compared with other types of pasteurising apparatus. They are inexpensive to install, but require a large amount of steam for effective working as, on account of the relatively small heating surface provided, it is necessary to raise the temperature of the heating medium to a much higher level than the temperature to which the milk is finally heated. This excessive heating often causes portions of the milk to be overheated, with a consequent alteration in chemical character. Some form of pump, driven either by steam or electricity, is required to pass the milk in a continuous stream through the apparatus. The action of pumping alters the texture of cold milk and affects the cream-line. The apparatus is illustrated in Fig. 147.



By courtesy of Hiron and Rempler, Ltd.

FIG. 147. "Silkeborg" Direct Drive Pasteuriser.

"Flash" pasteurisation possesses many serious disadvantages, particularly so with older types of apparatus. A uniform temperature is difficult to maintain, while variations in flow of milk cause fluctuations in the temperature to which it is heated. During the heating process a " cooked " flavour is often acquired. The nutritive value of milk is seriously impaired owing to chemical and physical changes which occur, due to the excessive heat to which the product is subjected, together with contact with air. Owing to the rapid passage of milk through the apparatus, it is not always in contact with the heating surface for a sufficient length of time to treat the article efficiently. Some milk does not even reach the required temperature. In addition, foaming, a condition to be avoided in any pasteurising plant is extremely prevalent.

There is no doubt that " Flash " pasteurisation does, if correctly carried out and supervised in an efficient manner, reduce the number of bacteria contained in milk and, to the extent that these are destroyed, improves its keeping quality. The commercial advantage of such improvement is seriously offset by the alterations which take place in milk and the effect which such heating has upon " cream-line." No reliance can be placed upon the total destruction of any pathogenic organisms which the milk may originally contain owing to the possibility of variations in temperature which may allow some of these bacteria to escape destruction. It is thus impossible by this method to attain the satisfactory results which should follow efficient pasteurisation of milk. Legislation is required to prevent the sale of milk treated by this process, as such method cannot guarantee continuously a " safe " milk. " Flash " pasteurisers are sometimes used for the purpose of pre-heating milk when the low-temperature process is employed, although in such instances they work at greatly reduced temperatures.

Two modifications of " Flash " pasteurisation have recently been introduced within recent years, which possess the advantages of simplicity and economy without any of the disadvantages outlined above. These systems are :

(1) " High-temperature, Short-time " Process.
(2) Stassanisation.

These processes are discussed later in the chapter (see pages 315 and 339).

(2) **" Continuous-flow " Process.** Although this method is termed " Continuous-flow," it must not be confused with the " Flash " method of treatment. The general principle underlying this process is that milk is allowed to flow through the apparatus, arranged so that the liquid is pumped at a regulated speed and designed so that it is retained at the requisite temperature of 145° to 150° F. for a period of thirty minutes during its progress through the apparatus. Milk, before entering the apparatus, is generally pre-heated to the requisite temperature, and the quantity passing through is sufficient to prevent the temperature falling more than two or three degrees. The apparatus is sometimes surrounded with a hot-water jacket to maintain the temperature of the milk. The flow, although continuous, is retarded as it has to pass through a series of tubes or between baffle-plates before leaving the apparatus. To ensure that milk is in contact with the heating agent for the required thirty minutes, the plant is arranged so that a volume of milk equal to the capacity of the apparatus passes through during that period.

This method of pasteurisation possesses many advantages. " Continuous-flow pasteurisers are generally of simple design and afford easy working and cleansing, while the temperature of milk is controlled within close limits during treatment. The owner of this type of plant is therefore able to produce milk which has suffered little appreciable change during processing although, in spite of this, the apparatus cannot be considered highly efficient. Hamill has drawn attention to the comparative efficiency of this design. Following investigation, he declares that this type of plant, having an efficiency of 50 per cent. under normal working conditions, could be classed as highly efficient. He also points out that efficiency at a given rate of flow can be defined as the ratio of the shortest time during which any particle of milk passes through to the time during which a quantity of milk equal to the contents of the apparatus flows through, the whole being expressed as a percentage.

The number of bacteria contained in milk is considerably reduced, but the great disadvantage of this method is that no complete destruction of pathogenic organisms can be guaranteed. Many "Continuous-flow" pasteurisers are in use which do not prevent some portion of the milk passing through in less than the specified time. Faulty design has much to do with this defect, but convection currents, swirls in milk, and variations in velocity also permit some milk to escape adequate heating. This system must retain milk for the full period of thirty minutes at the required temperature to be 100 per cent. efficient, and such efficiency cannot be obtained in practice.

The absence of any guarantee that all pathogenic bacteria contained in milk are destroyed by this method of treatment prevents it giving entire satisfaction from a public health standpoint. From the commercial point of view, the system affords certain advantages as, with the consequent reduction in bacterial content of milk, keeping quality is considerably improved. No method of pasteurisation can, however, be recommended which does not destroy all the more usual types of pathogenic organisms likely to be found in raw milk. In addition, the slight reduction of temperature which generally occurs as milk moves through the apparatus is not in accordance with the principles of efficient pasteurisation.

(3) **Low-temperature Process.** This is one of the recognised methods for satisfactory treatment of milk to be sold as "Pasteurised" under the terms of the Milk (Special Designations) Order, 1936 and the Regulations of 1941. The method may be employed in two ways, according to circumstances :

(*a*) *"Batch" Pasteurisation,* in which separate holders may be used either singly or coupled together. This is an economical proposition for the small dairyman.

(*b*) *"Multiple Compartment" Method,* which is generally adopted by large dairy firms. The holding process is carried on without any loss of continuity in the supply of milk to the cooler and bottling machines.

(*a*) **"Batch" Pasteurisation.** This method of treatment is quite suitable for the distributor with a relatively small trade. If such plants are properly designed and constructed they will give uniformly good results, always provided they receive adequate care and attention. The process consists of heating, holding, and, if desired, cooling milk in a single tank. A plant of this type is capable of handling from 50 to 300 gallons of milk per day according to the number of tanks provided, and is both reasonable in cost and economical in operation.

The holder proper is a single tank, in which milk is retained at a temperature of 145° to 150° F. for thirty minutes. The tank, which may be constructed in various sizes containing from 15 to 100 gallons of milk, is generally cylindrical in shape, and is surrounded with a jacket to which low-pressure steam or hot water may be admitted for heating purposes. The jacket should be designed so that any heat loss during the holding period is eliminated and so that when correct temperature has been attained and the holding period commenced, there should be no fall in this temperature. It should be designed to hold a given quantity of milk and be free from recesses or pockets which might harbour bacteria or prevent the whole quantity of milk being held at the requisite temperature. It should be easy to clean, be fitted with adequate temperature controls, which are usually hand-operated and possess an adequate heating surface to ensure rapid heat exchange. Milk is agitated during the process to secure uniform heating, but such agitation should be insufficient to affect the subsequent rising of the cream after treatment. The steam or water in the jacket is at a higher temperature than milk need attain, but immediately the liquid reaches pasteurising temperature the steam or water supply is disconnected and it remains slightly above 145° F. throughout the holding period. In some types of plant, provision is made for circulating the heating medium by mechanical or other means in order that suitable temperatures may be attained. In this manner, any possibility of " hot " or " cold " spots is eliminated and temperatures of heating medium and milk are efficiently controlled. Milk should be preheated prior to holding, otherwise some milk will have to remain in the holder for an hour or even longer before it is finally cooled and bottled. This lengthy waiting period may induce a " cooked " flavour. After treatment, cooling may take place by circulation of cold water through the surrounding jacket, but this procedure naturally retards cooling owing to the bulk of milk to be treated, and is not conducive to low bacterial counts, good flavour, or satisfactory cream-line. Cooling should preferably be carried out in a separate unit, but the water jacket may be used to supply a primary cooling before the liquid passes to the final apparatus.

With this type of apparatus it is essential to ensure that no milk is held *outside* the heated jacket of the holder, and it is also desirable that pumps and pipe-lines used for untreated milk should not be used for milk after treatment. Such auxiliary apparatus should be washed and sterilised between the filling and discharging of the milk. The holder may be filled and discharged either by hand or automatically as desired, and some means of accurately recording the temperature of the milk is essential.

Distributors treating large quantities of milk daily cannot make satisfactory use of the " Batch " pasteuriser, as coupling several small holders would not render pasteurisation of large quantities of milk a commercial proposition.

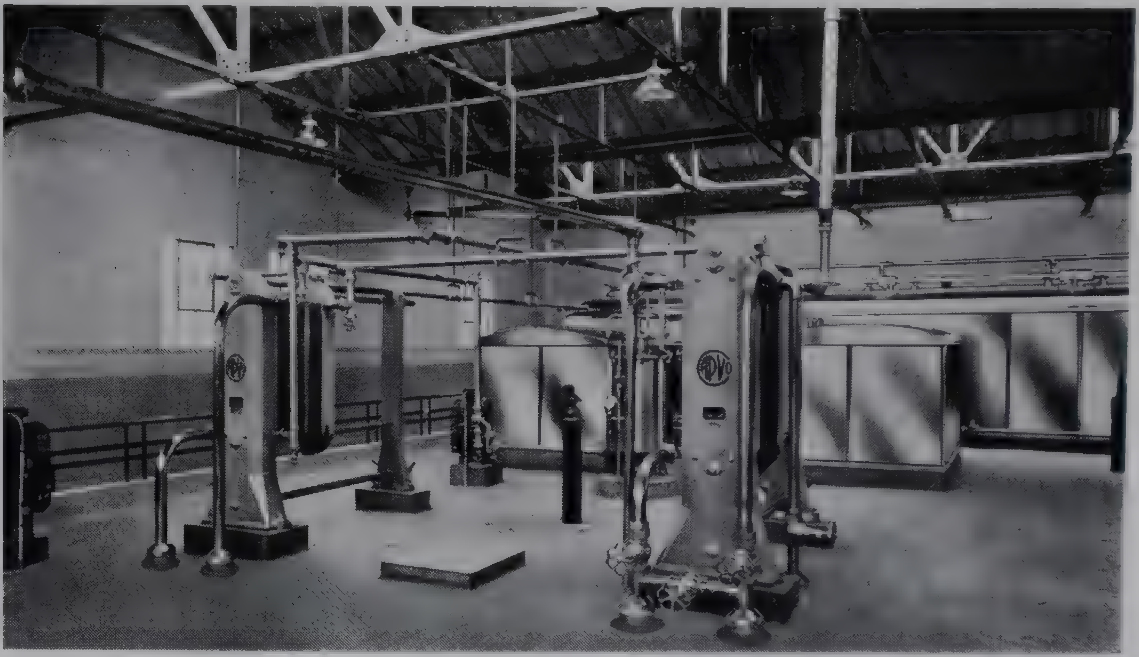
(*b*) **" Multiple Compartment " Method.** This process is really an extension of the " Batch " system, the apparatus is being provided with several compartments or tanks which may or may not be housed within one framework. On account of the large quantities of milk which the bigger operators require to treat, this larger type of plant has been universally installed in such dairies. Usually, efficient controls are provided and operations are fully mechanised in order to obviate risk of faulty treatment.

Continuous action is obtained by means of a number of large tanks or holders coupled in such a way as to ensure that the outflow of treated milk is continuous. The simplest method in which continuity can be obtained is by the provision of three holding tanks so arranged that, while the first tank is being filled, milk is being held in the second, and the third is being discharged. These three tanks should possess the same capacities, and the inflow and outflow of milk should be arranged so that it will require exactly thirty minutes to fill or discharge each tank. This will ensure a holding period of exactly thirty minutes. There are two major objections to such a method :

(*a*) It may happen that some milk may be held for a longer period than thirty minutes.

(*b*) A period of approximately one hour must elapse from starting-up the plant before the pasteurisation of any one batch of milk is completed.

To overcome these defects it is necessary to provide a sufficient number of tanks to enable the period taken for filling and discharging to be considerably reduced. This is attained by filling a set of containers in turn with heated milk, leaving each container undisturbed for the necessary holding period and allowing each to discharge in strict rotation to the cooler.



By courtesy of the Aluminium Plant and Vessel Co., Ltd.

FIG. 148. Modern Pasteurising Plant.

There are three main types of apparatus used in the " Multiple Compartment " process :

(*a*) First type, consists of a set of containers, each being filled through its own valve from a common supply pipe and discharging through same or through a separate valve into a common main. The principal fault of this type is that it allows untreated milk to come into contact with milk already pasteurised, as containers are frequently emptied by means of a filling valve. A faulty valve may also cause the contamination of treated milk. In modern apparatus of this type, inlet and outlet valves are kept apart and, by means of the special leakage grooves provided, any milk which escapes past the valves falls clear of the system.

(*b*) Second type, consists of a set of six containers which rotate systematically in a clock-wise direction in relation to common filling and discharging devices from which each compartment is disconnected. In some cases the compartments are fixed, and filling and discharging devices revolve. Preheating of milk is usually carried out prior to the filling process. The revolving type is very popular in this country in the form of the *Tarbet* holder. This apparatus embodies the idea of complete isolation of milk which is being held from either the raw or treated product. Since its introduction in 1922, this type of plant has remained substantially unaltered in design. In practice, the flow must not be excessive or danger will arise of milk flowing over from one compartment to another. Care must also be taken to ensure that the receiving tank into which milk is discharged after holding is not left uncovered. A great advantage of this system is that no amount of leakage from valves can affect the process.

(*c*) A third type of holder is known as the "Individual Tank System." With this type each compartment is a separate tank, which may hold any quantity of milk up to 1,000 gallons. The tanks are independent, but have common filling and discharging devices. They are often open at the top, being provided with covers, and are insulated against heat losses.

With any of the types mentioned, pasteurisation cannot fail to be satisfactory, always provided that the milk is delivered to the apparatus at the correct temperature, that heat losses are properly guarded against, and that there is no misuse due to failure of the human element.

As regards mechanical and constructional details, the following points require attention. The formation of excessive *foam* in holding tanks is a constant source of difficulty when clarifiers or centrifugal cleaners are employed. Prevention of such foaming is essential, as bacteria in foam may survive the process owing to the temperature of such foam being 8–12° F. below that of the remainder of the milk. This can be prevented if milk flows quietly into the tanks from below. *Inlet and outlet valves* may be either hand or mechanically operated. When mechanical valves are provided, they are generally controlled by a timing mechanism. Valves require careful attention, as no valve has yet been constructed which will not show signs of wear after prolonged use. It is essential that no unpasteurised milk should find means of access into milk which has already been treated. Arrangements are generally made for any leakage of milk from closed valves to be conducted to a separate tank. *Agitation* is commercially necessary to prevent cream rising and also to prevent any membrane forming on the surface of milk during heating. From the public health point of view, the provision of agitators complicates the cleansing of holders, and further, if such agitation is not properly and carefully carried out, exposure of the milk to air will be increased. This favours destruction of the vitamins and may impair the flavour of the milk. The "Multiple Compartment" type of plant should be constructed in as simple a manner as possible. Milk should flow from the receiving tank by *gravity* or other simple means throughout all processes. Many large plants operate on the *vacuum and compressed-air system*. Milk, instead of being pumped or falling by gravity, is carried by means of a vacuum to the holders and is expelled from there through the cooling system by means of compressed air. The charging main is under vacuum, the holder is at atmospheric pressure, and the discharging main is under positive pressure. The flow of milk is not controlled directly, but a *timing mechanism* controls the application of the vacuum and compressed air to each tank in turn. This system possesses the following advantages:

(*a*) It renders the holding process independent of valves.
(*b*) It simplifies control.
(*c*) It allows the entire process to be carried out in a closed circuit free from air-borne contamination, oxidation or evaporation.

In many plants designed in this manner, tanks are grouped together within a common framework. The containers are usually filled from the bottom and emptied from the top, discharging upwards through a stand-pipe. When one holder has been filled, the vacuum is automatically transferred to the other tanks in turn, these being filled in strict rotation. Each tank is allowed

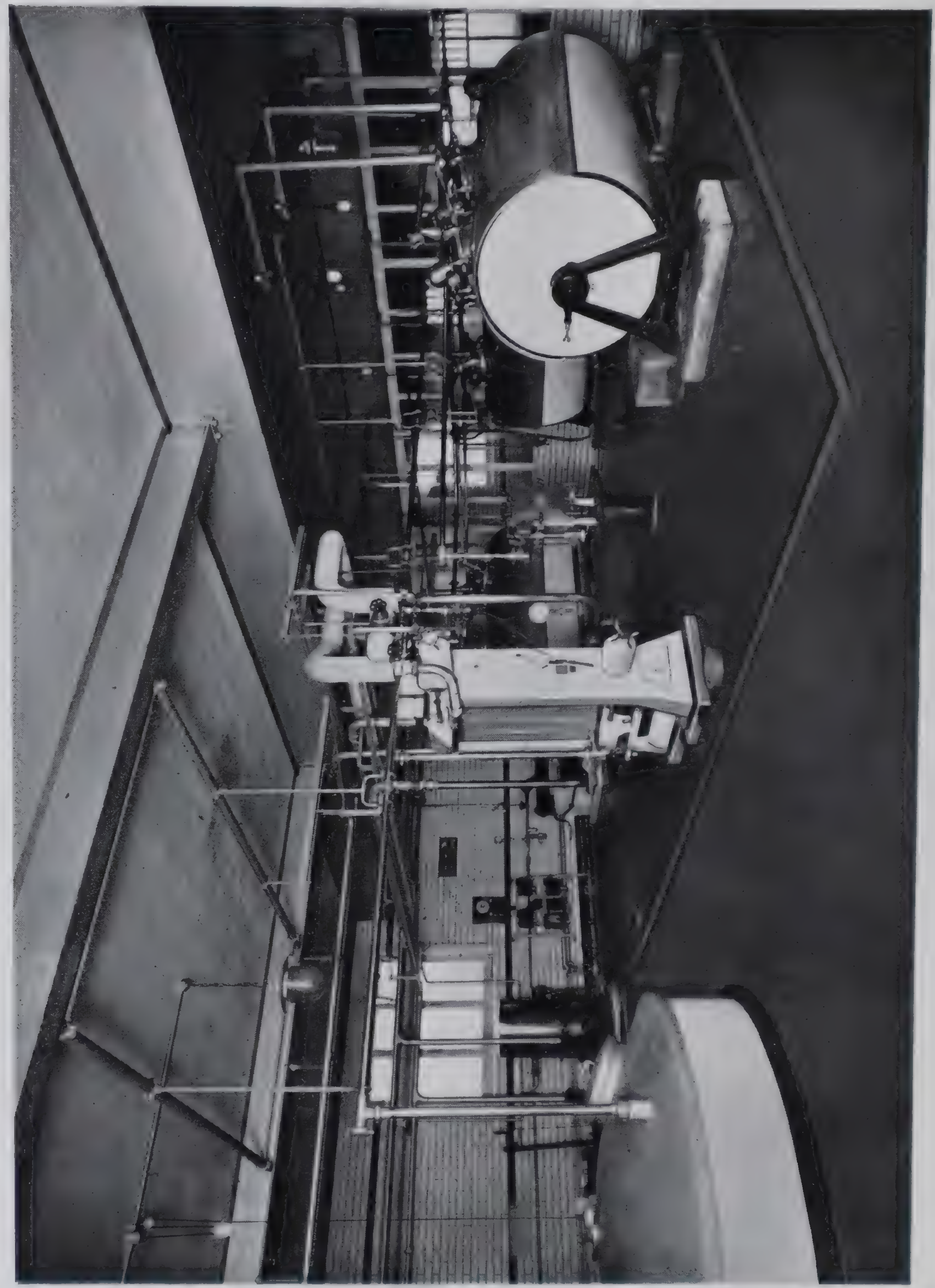


FIG. 149. A.P.V. Vacuum Pasteurisation Plant.

By courtesy of the Aluminium Plant and Vessel Co., Ltd.

to remain full for the predetermined period of thirty minutes, and, when this time has elapsed, each is discharged by means of compressed air, which has been previously washed and filtered. When the tanks are filled and under reduced pressure, the escape of "off" odours is facilitated. The only leakage which can take place is from milk which has already been treated into milk which is undergoing treatment. It is essential that the reservoir from which raw milk is drawn should be at a lower level than that of the holders, in order to prevent the milk flowing into the holders during the processing.

(4) **Pasteurisation in Bottles.** Although this method is actually a modification of the low-temperature system and as such can be carried out in conformity with the conditions specified in the Milk (Special Designations) Orders, the pasteurisation of milk in bottles has never made much progress in this country. It has been practised in America on a large scale, but the number of distributors using it has fallen considerably, and very few plants are now operating on these lines either there or in this country. The advocates of this system rightly claim that milk so treated cannot be contaminated either during or after treatment or during subsequent operations prior to delivery, and this is an important public health advantage. Milk is also stated to possess better keeping qualities than those imparted by pasteurisation in bulk. This system would be of more use if milk could be so treated at the farm immediately after production. Owing to the outlay required it could not be attempted by the milk producer at the present time, but steps are being taken to provide small plants for producer-retailers at a reasonable cost.

Milk may be treated in the bottle by one of two methods, as follows :

(*a*) It may be filled hot into bottles direct from the bottle washing machine. The bottles are then submerged in tanks containing water at a temperature slightly above pasteurising level. Bottles finally pass through cold water for cooling purposes.

(*b*) The method now generally practised in this country by those few distributors who pasteurise their milk in bottles is to fill the liquid heated to a temperature of 146° F. into hot bottles which are then sealed. Filled bottles are next passed through a hot-air chamber, the temperature of which is maintained at 146° to 147° F., their passage through this chamber being arranged to occupy exactly thirty minutes. Treated bottles are cooled in stages by means of water of varying temperatures to a final temperature of 40° F. Milk treated in this manner is said to have—

(i) Very low bacterial content.
(ii) General absence of *Bacillus coli*.
(iii) Good cream-line.
(iv) Exceptionally good keeping qualities.

Pasteurisation in bottle may be regarded as a theoretically ideal method, and one which should be more widely practised. This system of treatment is further considered on pages 308 to 312.

(5) **High-Temperature Short-time Process.** Owing to the fact that this method of treatment possesses certain commercial and economic advantages, innumerable experiments have been carried out in the past in order to discover how the system could be adapted to the treatment of milk in order to render it safe from a public health viewpoint and, at the same time, be commercially successful. Although up to a few years ago the low-temperature method of processing was favoured in official circles, one must admit that the modern short-time method can, following the conclusion of numerous experiments which have been made both in this country and abroad, be safely recommended as a standard method of milk treatment. So much so that in 1941 the Minister of Health, empowered by the Food and Drugs Act, 1938, issued new Provisional Regulations known as the Milk (Special Designations) Regulations 1941, which dealt with the production of milk

by this method under the designation "Pasteurised." These Regulations permit the employment of the short-time method, always provided that milk is retained at a temperature of not less than 162° F. for at least fifteen seconds, that the apparatus is fitted with full thermostatic control and that a suitable device is provided to divert the flow of any milk which has not been properly held.

This revolutionary change in official opinion has enabled the distributor to pasteurise milk in a plant which is less cumbersome, lower in capital cost and which is able to provide the public with a safe milk, always provided that it is properly used and maintained. It must be emphasised, however, that with the small margin of safety provided, much greater precision must be achieved than was required or considered necessary with lower temperatures and longer holding periods. Nor must it be forgotten that the Regulations are "Provisional" at the present time, and it would be a great pity if the employment of unsuitable plant or methods for treating milk in this way prevented their future permanency. Indeed, there would appear to be no reason why the process should not have come to stay if properly carried out, and it is quite likely that if its employment is confirmed, after an extended trial period, it may well oust other accepted methods from their present pre-eminence.

The forerunners of the present system were "*Flash*" *pasteurisation* and the "*Continuous-flow*" *process*, both of which were capable of materially reducing the bacterial content of milk treated by their agency but which did not give any guarantee that the final product was free from pathogenic organisms. Scientific and accurate control presented considerable difficulty, and public health authorities have always disliked the principles of these systems and could not permit their general adoption for the production of pasteurised milk. The later development of such apparatus together with more sensitive and reliable control devices has altered the attitude of the Minister of Health towards the short-time process and, while this is accepted, it must be admitted that part of this change of mind is no doubt also due to a desire to procure economies of fuel and labour in many processing plants and obtain a smaller, more readily made plant with a view to the wider employment of the process.

(6) **Vacuum Pasteurisation.** In America, a system of vacuum pasteurisation has been recently introduced to the dairy industry. This method is described as a system of pasteurising and conditioning liquids, especially milk and cream. The important object of the process is stated to be to provide an improvement in the flavour of milk in conjunction with effective treatment. It is stated that this process augments and magnifies the volatilising effect of normal pasteurising and cooling processes in relation to off flavours resulting from feeding materials and other influences. It is also claimed that exhaustive tests of the process have been made, and fifteen installations in dairy plants have been tested for two years with highly successful commercial results.

The principle of vacuum pasteurisation is mixing milk under compression, this being immediately followed by a sudden and spontaneous expansion in a finely divided state within a chamber of reduced pressure. The separation of treated milk and its contained off-flavours in the form of vapours provided by the sudden transition from a stage of compression to a state of expansion is maintained by heating the walls of the separating or vacuum chamber. In addition, the instantaneous pre-cooling effect upon the product accompanying its expansion within the vacuum chamber is described as an important factor in preserving the desirable body characteristics of the liquid, even when inordinately high pasteurising temperatures are utilised, such as could not be normally employed without being detrimental to the product.

The process provides the means for the heat treatment of milk within the conventional pasteurising range and at particularly high temperatures, i.e. above the normal "Flash" range and within the sterilisation limits of 200° to 250° F. or even higher. In other words, pasteurisation at high temperature, that is, above boiling-point of the fluid at normal atmospheric pressure, is accomplished with vacuum pasteurisation.

Plant Design

The design of any pasteurising plant is dependent upon certain conditions. Most important among these are :

(1) Mechanical Effects of the Process.
(2) Metal Surfaces.
(3) Temperature Control.
(4) Thermophilic and Thermoduric Organisms.

(1) **Mechanical Effects of the Process.** Pasteurisation exercises certain important mechanical effects upon the milk so treated. The cream-line, which is one of the most prominent commercial factors, is chiefly affected. To preserve cream-line in milk after treatment, it is essential that cold milk should not be pumped or agitated more than is essential. In designing a plant, arrangements should therefore be made for all essential pumping to be carried out prior to holding during the time the milk is warm, by means of a suitable rotary pump. If it is desired to carry the milk through the plant by gravitation, it may be necessary to pump the liquid into receiving tanks, but care should be taken to ensure that it is never pumped after pasteurisation or following the subsequent cooling. Stirring or agitation in an equalising tank is said to reduce cream-line as much as 10 per cent. of the total volume. Cooling also exerts an influence upon the milk (see page 290). The pre-heating and holding processes should be carried out in the absence of air, but aeration of milk in the receiving tank and during cooling is desirable, provided that such aeration can be carried out without risk of contamination.

(2) **Metal Surfaces.** The possible effects produced by the metal surfaces with which milk comes into contact are important and require consideration. The essentials of metal used for dairy purposes are :

(1) It must be easily cleaned and scoured and provide a hygienic surface.
(2) Metallic contamination of milk must be impossible.
(3) It must be a good conductor of heat.
(4) Must be resistant to any form of corrosion.
(5) Be easily and cheaply fabricated.

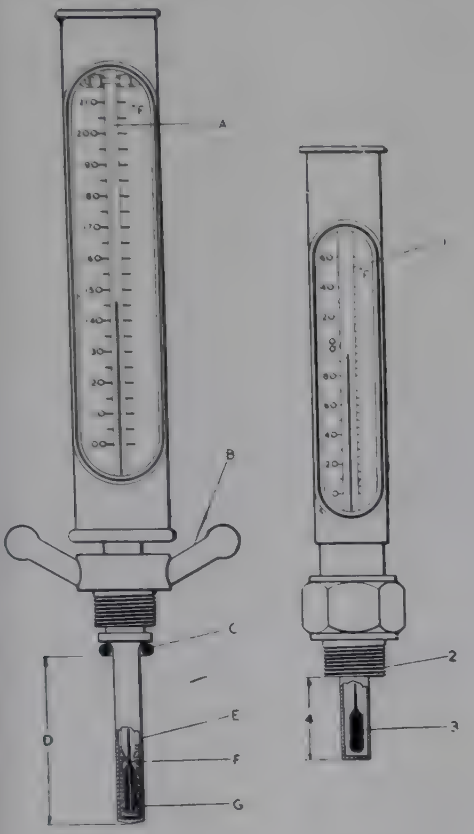
The first essential is a surface which can be *easily cleaned and scoured.* Secondly, the possibility of metallic contamination of milk must be avoided. Fortunately, with the choice of metals now at the disposal of manufacturers and the quality of such metals, risk of metallic contamination has been reduced to a minimum. *Tinned copper* has been employed for many years for dairy purposes and is satisfactory if the tin used is reasonably free from lead, always provided the covering remains intact. Frequent cleansing operations ultimately tend to destroy the coating of tin, and the copper thus exposed will influence the flavour of any milk with which it comes into contact. Pure tin is slightly soluble in milk, but in itself has no effect upon flavour. It is impossible to employ equipment manufactured solely from this metal on account of its inherent softness; for this reason it is usual to employ a copper base to add strength to the finished article. Tinned copper equipment is very serviceable for handling cold milk, but it is not suitable for holders where the removal of burnt-on milk solids usually requires the employment of strong alkalies and friction. Cleansing materials readily eat away the coating of tin, as will abrasive action, and before such equipment can be solely employed, improved methods of tinning copper require to be developed. *Aluminium* is a suitable metal for use in pasteurising plants, and is now largely employed for the construction of all dairy appliances. It resists the action of milk of low acidity and does not influence flavour, but unless aluminium is pure, impurities present may render it subject to pitting. It is, however, extremely sensitive to electrolysis in contact with certain metals and is attacked by strong alkalies. It can be easily cleansed without injury by means of ordinary soda to which has been added a little water-glass or with properly inhibited alkaline or acid cleaners. *Chrome nickel steel* has not been used in the manufacture of dairy apparatus for any length of time and, while up to the present it appears to be generally satisfactory, its employment over a more lengthy period may reveal limitations which are not at present apparent. It possesses most of the qualities of stainless steel, but is very vulnerable to electrolytic action when in contact with certain metals. It must possess a highly polished surface and be free from iron oxide. *Monel metal* is also a useful material for dairy purposes. The ideal material is *stainless steel*, as this resists the detrimental effect of lactic acid and of the various detergents which may be used in cleansing. It cannot be injured by scouring, is easily cleansed, will not stain or corrode, has no electrolytic action, and does not form any salts which are soluble in milk or injurious to health, while its bright appearance is permanent.

Mechanically, these latter metals are more resistant to wear than are tinned copper or aluminium, therefore their working life is extended while less repairs to plant are required. The internal surfaces of such equipment are not susceptible to deterioration due to impact as is the case with glass-enamelled apparatus, although they are quite as hygienic as glass; the only objection which can be raised to their use is their cost, which is more than amply repaid by economies obtained from their employment.

(3) **Temperature Control.** Accurate temperature control is an absolute necessity during pasteurisation, either by the low temperature or short-time methods. Otherwise, however well designed plant may be, its suitability for the work for which intended will be nullified unless such means of efficient control are provided. The owner of the plant requires to be assured that the milk is not overheated with a view to preserving the cream-line, while it is also essential, from a public health standpoint, that milk should not have been held at too low a temperature or for too lengthy periods.

The Milk (Special Designations) Order, 1936, and the Regulations of 1941 require the provision of efficient means of temperature control suitable to the requirements of the licensing authority. Without the aid of suitable instruments, efficient pasteurisation is impossible. Most plants are provided with indicating thermometers as standard, but these are not always correctly placed. The thermometer bulb should always be immersed in accordance with the maker's instructions and positioned to give a true reading of temperature. If not properly placed, readings may be influenced by metal surfaces adjoining the bulb. Correctly installed, there is no doubt that this type of instrument is more reliable than the recording thermometer, but all types require checking for accuracy at frequent intervals. Fig. 150 gives a diagrammatic comparison between a good and bad thermometer.

The provision of at least one recording thermometer must be insisted upon, preferably fixed at the combined outlets of the holder compartments. It is also advisable that one of these instruments should be provided to indicate the temperature of milk leaving the preheater and also in the pipe-line from cooler to bottling machine. In passing, it should be noted that where several recording instruments are fitted, these may be installed at a convenient point some distance from the actual point at which the temperatures are recorded. This allows them to be placed in good light where they may easily be inspected. Indicating thermometers should also be placed at similar points to check the working of recorders. Separate recording thermometers require to be provided for independent tanks of "Batch" pasteurisers, while all these instruments should be kept locked to prevent any unauthorised persons tampering with them. Figs. 151 shows the correct position of temperature recorders on the plate heater type of plant and Fig. 152 on that in which a tubular heater is employed.



Note following desirable features :—

A. Calibration engraving on glass stem.
B. Provision for screwing thermometer into position by hand.
C. Hygienic sealing ring which may be sterilised.
D. Satisfactory length of pocket providing for complete immersion.
E. Groove showing minimum immersion length.
F. Blue streak indicating British "Normal" glass
G. Metallic packing to eliminate time lag caused by an air space.

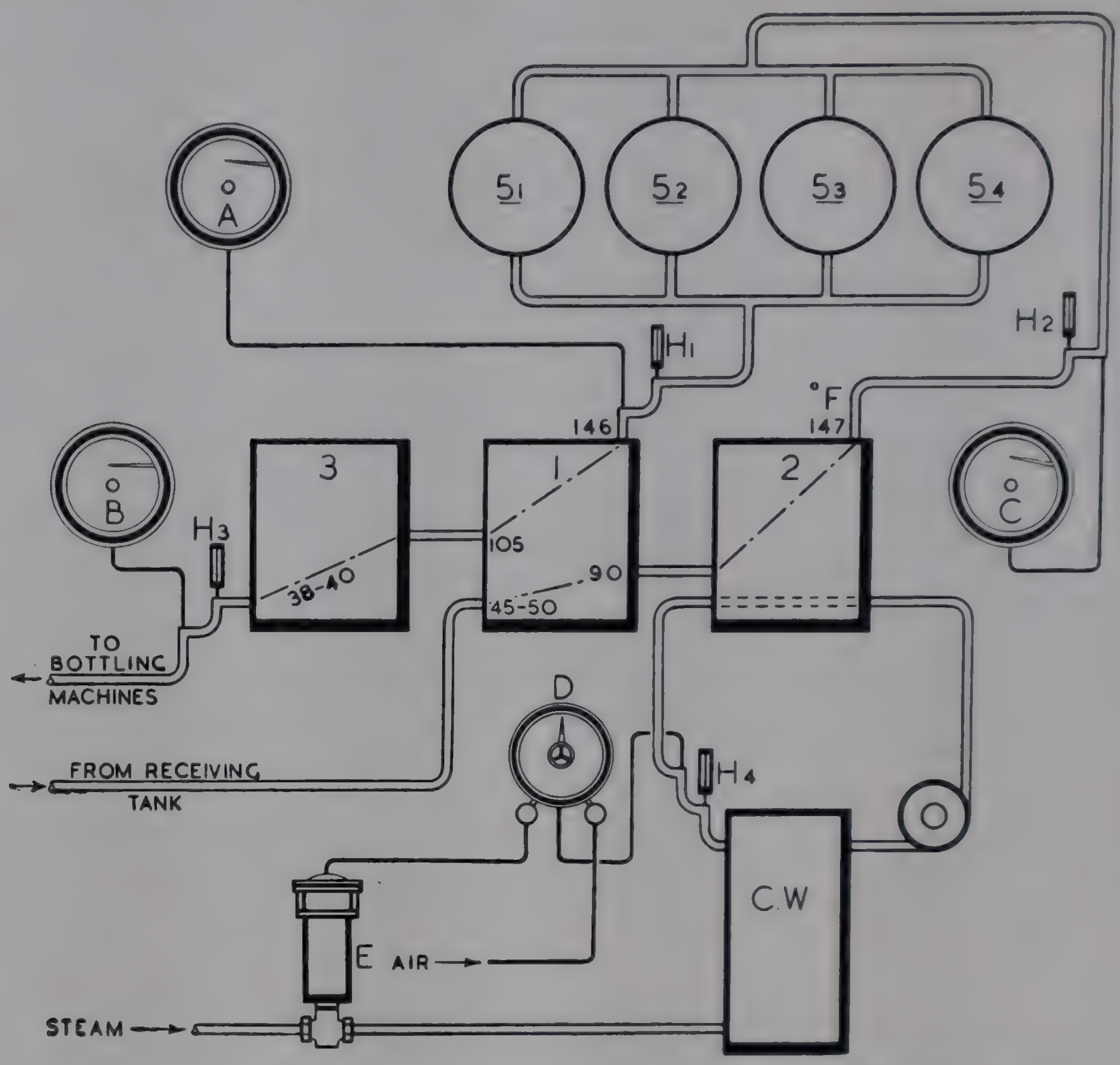
Faults frequently seen in Dairies :

1. Glass stem not engraved. Error possible through change of position of glass stem.
2. Threaded portion in direct contact with milk—not designed for easy cleaning.
3. Air space interfering with response of the thermometer to temperature change.
4. Insufficient immersion length.

By courtesy of Negretti and Zambra.

FIG. 150.

The charts used in recording thermometers are important. They should be printed on a sufficiently large scale so that the smallest variations in temperature and their duration may be discerned. Both time and degrees must be reasonably spaced, and one-sixteenth of an inch per degree Fahrenheit is recommended and should be regarded as a minimum. The important ranges of temperature are from 120° F. upwards, while the time spacing is equally important in order that holding times of separate tanks may be properly recorded and checked. There is a tendency to record the temperature of milk leaving the holder and its temperature after final cooling on the same chart by means of double pens. This method cannot be recommended as charts must of necessity have a range from 30° F. to about 175° F., and, if one chart is employed for this purpose, the divisions are naturally extremely minute. It is much more desirable for charts to be used for recording the pasteurisation temperature only and scaled from 130° to 160° F.



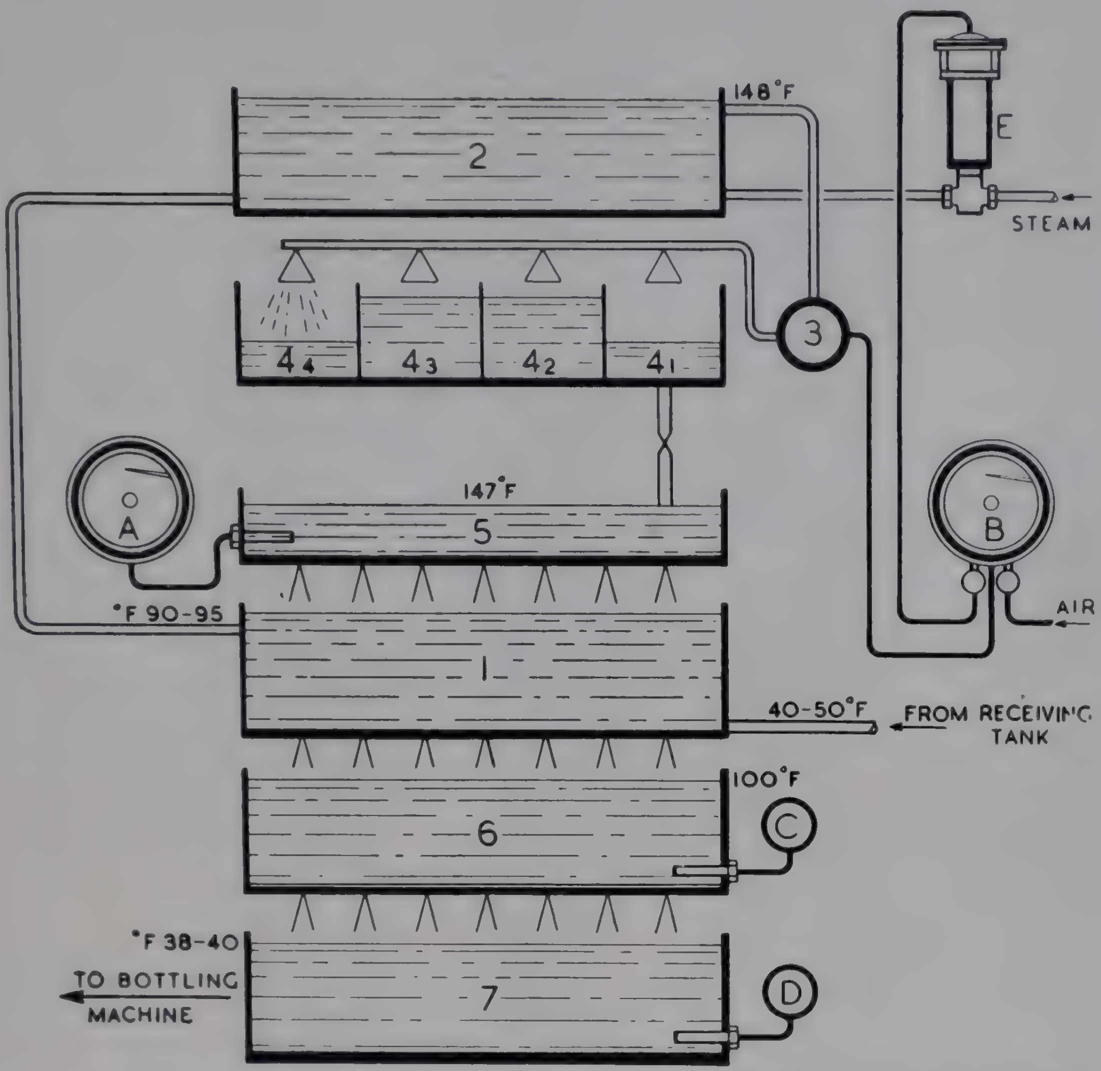
By courtesy of Negretti and Zambra.

FIG. 151.

A. Temperature recorder for milk leaving holding tanks, 5_{1-4}.
B. Temperature recorder for milk leaving cooler section (3) of heat exchanger.
C. Temperature recorder for milk leaving heater section (2) of heat exchanger.
D. Automatic temperature controller for circulating water.
E. Valve operated by D and controlling temperature of circulating water.
H_{1-4}. Mercury-in-glass thermometers.
5_{1-4}. The four compartments of the holding tanks of the retarder.
1. Preheater section of heat exchanger.
2. Heater section of heat exchanger.
3. Cooler section of heat exchanger.
C.W. Circulating water heater.

Recording thermometers employed for dairy work must be adjustable.

and should be accurate to within at least one degree Fahrenheit ; in addition, they should be moisture proof. Mercury-actuated instruments are provided with charts with uniform graduations, but those employed with vapour-type instruments have divisions which gradually increase in width as the temperature rises. This latter type of instrument is more sensitive than one which relies upon the use of mercury. Charts should provide for a twelve-hour rotation and be printed with one degree divisions between 145° and 150° F., in order to give a clear indication of temperatures attained.



By courtesy of Negretti and Zambra.

FIG. 152.

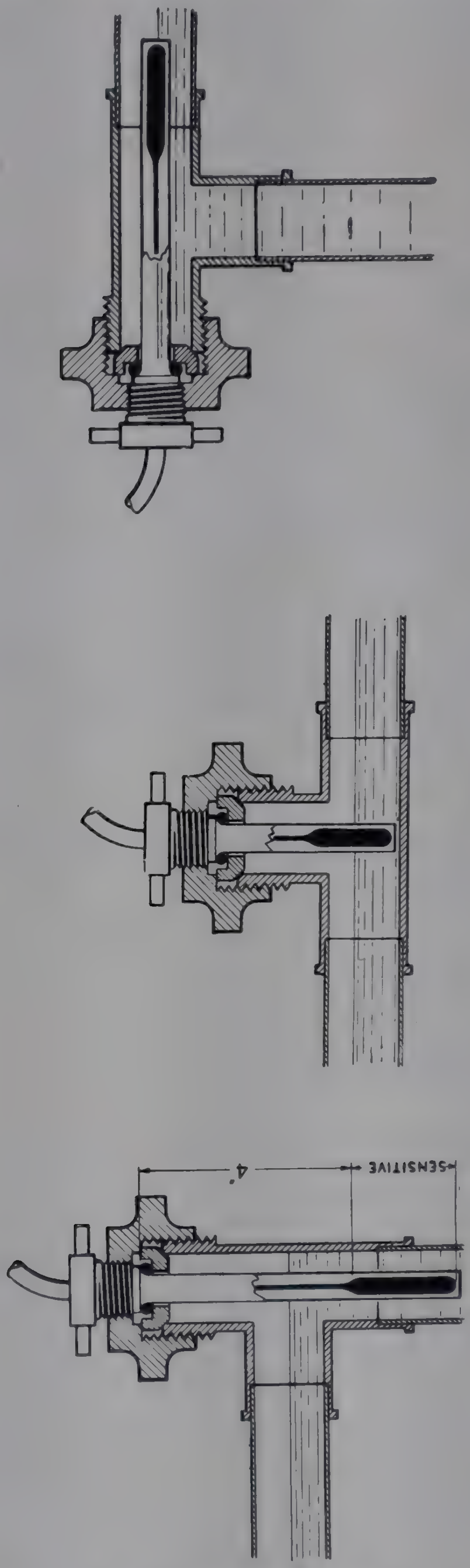
A. Temperature recorder for milk leaving compartments of retarder 4_{1-4}.
B. Recorder controlling regulating valve E governing admission of steam to heater (2).
C. and D. Indicating thermometers.
1. Preheater. 2. Heater. 3. Filter. 4_{1-4}. Compartments of the retarder.
5. Collecting tank. 6. Cooler. 7. Balance or cold milk tank.

With all recorders, correct immersion of the bulb is again essential. Fig. 153 shows the correct method of bulb immersion and also demonstrates how these may be incorrectly installed.

As already mentioned, two types of recording thermometers are employed. These are the vapour-pressure and the mercury-in-steel instruments. The advantages of the former are :

(*a*) Quick response to changes of temperature.
(*b*) An increasing scale which gives wide graduations at pasteurising temperatures.
(*c*) Flexible connection between bulb and instrument.

This type is said to possess the tendency to introduce an error dependent on barometric pressure variation, due to the inherent low internal pressure, while accuracy is affected by the difference in level between the bulb and the instrument itself. The pen moves rapidly, and this may overshoot and suggest that errors in control are greater than is actually the case. The overall accuracy does not appear to be better than ± $1\frac{1}{2}$ to 2 per cent.



A Correctly installed thermometer bulb. Note sensitive portion is completely immersed in milk.

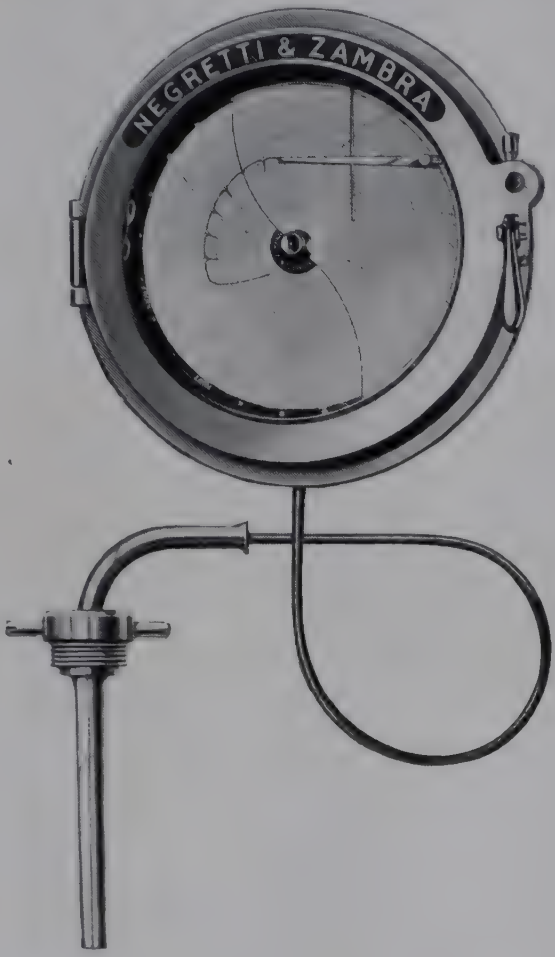
B C Incorrectly installed thermometer bulbs. Note that sensitive portion is not completely immersed in either case.

FIG. 153.

By courtesy of Negretti and Zambra.

The speed of response to changes in temperature when the mercury-in steel type is employed is slightly less than with the vapour-pressure operated instrument. Uniform graduations are provided which are slightly larger than the one-sixteenth of an inch suggested as a minimum by the Ministry of Health, while their high internal pressure renders them immune from variations due to changes in barometric pressure. Their overall accuracy is higher than the vapour-pressure type.

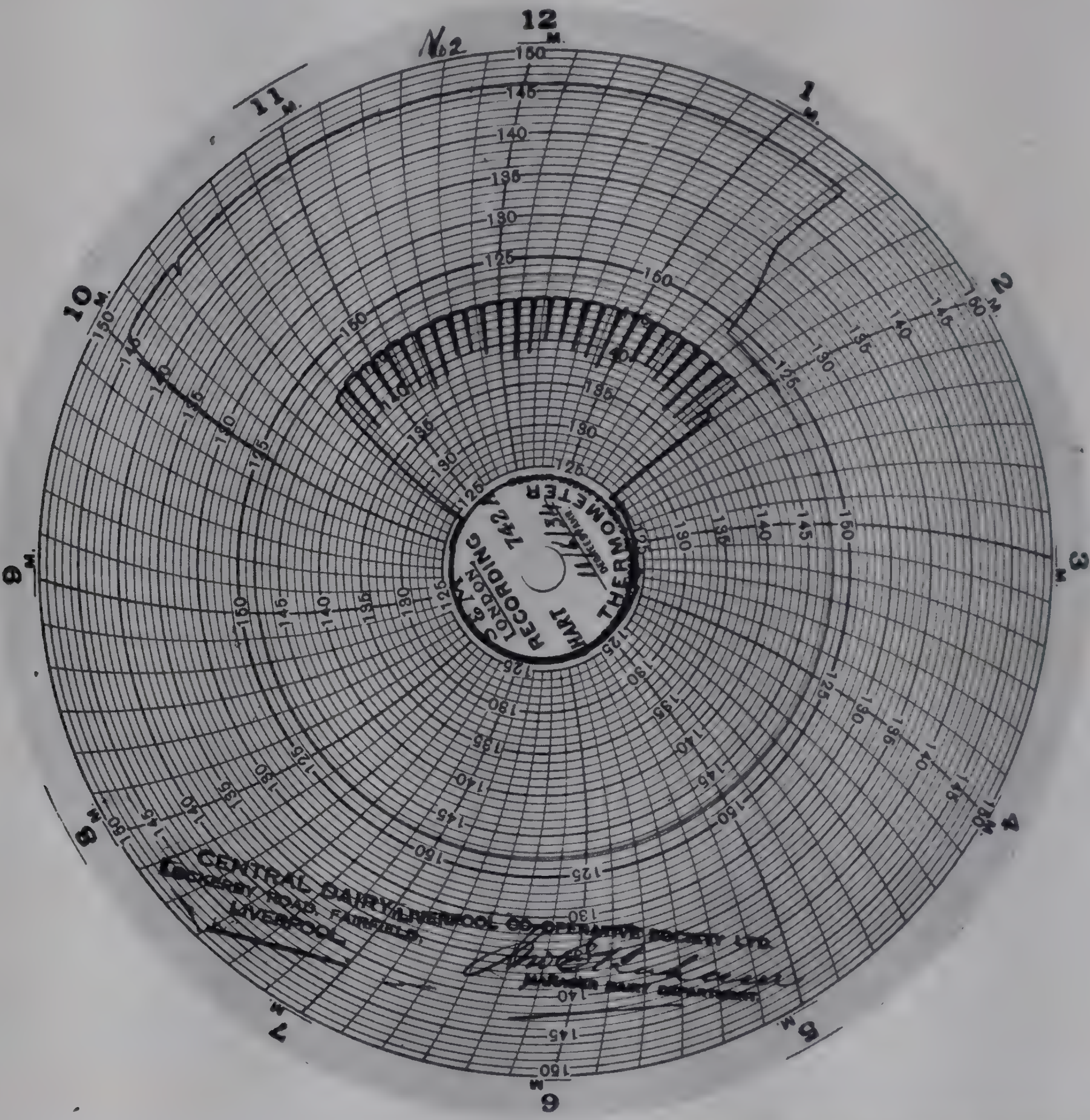
Fig. 154 shows a standard type of temperature recorder while the temperature-control chart illustrated in Fig. 155 demonstrates the necessity for strict control to within a fraction of a degree when pasteurising. The upper of the two lines shows the temperature of the milk entering the holder, the lower section showing the temperature of milk leaving the various compartments of the holder. The several drop lines indicate the change-over from one compartment to another as each is emptied. It will be observed that there is no drop in temperature during the holding period, which is as it should be. It is interesting to note that the varying length of the drop lines shown on the chart actually illustrate the distance of the various compartments from the central control. The compartments farthest away show the longest drop lines, which indicate that the milk has taken slightly longer to reach the bulb of the recording thermometer which is indicating the temperature.



By courtesy of Negretti and Zambra.

FIG. 154. "Mersteel" Temperature Recorder.

Having considered the measurement of temperature, it is now necessary to deal with methods of temperature control. Pasteurising controllers are nearly always of the air-operated type, as by this means throttling control is conveniently provided, although the system best suited to any particular apparatus depends upon the design of the plant and operating conditions. As an instance of this, when the heating medium is circulated by means of a pump, a different type of controller is required than is necessary for plants where the free circulation of water is employed. A small, self-contained compressor is provided, supplying air at a pressure of 15 to 25 lbs. per square inch. This is connected to the controller and from there to a diaphragm control valve inserted in the steam line to the heater. The compressor should always be located in a clean, dry position, while the air inlet to the apparatus should always be provided with a filter. The controller is adjusted to regulate the air pressure supplied to the control valve and just sufficient steam allowed to pass in order to maintain constant pressure. The bulb of the temperature controller may either be fitted in the milk outlet of the heater, which situation provides for direct control, or it may be placed in the water section thus maintaining the temperature of the circulating water, giving indirect control.



By courtesy of Cherry-Burrell, Ltd.

FIG. 155. Thermograph Chart.

The importance of temperature controlling instruments should never be overlooked, and their correct maintenance deserves special attention. Careful handling is essential, otherwise their active life will be considerably reduced and their accuracy decreased. These instruments should always be kept in clean condition, air strainers, moisture traps and air receiving tanks being blown out daily, while the compressor oil level needs to be carefully watched. These appliances will give years of service if properly cared for. Indeed, many dairies which have operated for a decade without any serious breakdown owe their immunity from trouble to the fact that both plant *and* temperature controllers have always been carefully maintained. Constant servicing of these instruments by their manufacturers is an aid to lengthy, active life. Operators of plants would do well to remember they are dealing with a scientific process of great importance to the health of the community and only by careful attention to temperature can the required result be achieved.

(4) **Thermophilic and Thermoduric Organisms.** Thermophilic (heat-loving) and thermoduric (heat-resistant) organisms are liable to be present in large or small numbers in all pasteurising plants unless great care is exercised. These organisms are seldom found in bulked supplies of raw milk exceeding 2,000 per millilitre in number, but they are capable of rapid increase at pasteurisation temperature, and are one of the difficulties likely to be experienced in the management of all low-temperature systems. After the plant has been in operation for a lengthy period (usually over five hours) they have been found present to the extent of several millions per millilitre. They can be spread throughout the plant in various ways, as follows :

(*a*) By excessively long running of the plant.
(*b*) By re-heating of pasteurised milk.
(*c*) By " backwaters " in pipe-lines and plant which enable the organisms to multiply rapidly.
(*d*) By the accumulation of foam in holder compartments, with consequent incomplete discharge of the vessels.

The presence of these organisms causes the incoming milk to be inoculated, and this contamination increases in proportion to the length of time during which the plant is in operation.

Thermophilic organisms were reported by laboratory workers in 1879 and, at first, were regarded as curiosities. They have been extremely troublesome in the routine commercial handling of milk, although they have no public health significance as producers of disease. Their presence in milk is undesirable, as they cause spoilage of the product whilst producing a high bacterial content, and they emphasise the fact that there are faults in plant design, operation and cleansing.

Trouble from these organisms is not generally experienced if the total length of run of the plant is less than five hours' duration. In many plants which are treating large quantities of milk, it is often necessary to discontinue processing for the purpose of cleansing all internal surfaces because of this danger. Indeed, treatment should be interrupted at least every three or four hours for cleansing purposes in order to prevent such troubles arising. The number of thermophilic organisms can be controlled by careful plant management. They develop as pasteurisation proceeds in the thin film of milk which covers the internal surfaces of equipment, multiplying rapidly. For this reason, it is vitally necessary to ensure that such internal surfaces are kept free from any milk film or " milkstone," from which the organisms may be distributed throughout the plant in ever-increasing numbers. Dead-ends, leaking regenerators, and tanks which do not drain thoroughly, should be eliminated, while the entrance of condensed moisture from unsterilised surfaces into milk should be prevented. The employment of air heaters above the surface of milk in the holder compartments is a preventative measure. Pasteurised or partly pasteurised milk should never be re-processed, and the cloths employed in filtration of hot milk should be frequently changed and used once only. Thermophilic growth is inhibited by the short-time process, which should be employed as a last resort, if other methods fail. Some of the organisms are acid-formers, so that an acid test alone is not a certain indication as to the necessity for terminating processing operations at any particular time. It should be mentioned that nutrient agar plates show a greatly reduced thermophilic count after milk, from which the sample is taken, has been stored in low temperatures. These organisms are remarkably susceptible to light, even weak daylight.

The number of *thermoduric organisms* present is chiefly dependent upon the bacterial condition of raw milk before treatment, and here the methods of milk production are intimately concerned. Anderson and Meanwell conducted experiments with a view to discovering the causes of the presence of such organisms in raw milk supplies, in which the following conclusions were reached :

(*a*) Effective utensil sterilisation reduces the numbers enormously.

(*b*) Wire gauze discs, when used in straining operations, are a frequent means of infection when improperly sterilised.

(*c*) Under ordinary farm conditions and without utensil sterilisation, more heat-resisting organisms are present in machine-produced milk than in hand-produced milk.

(*d*) The failure to cool milk immediately after production encourages this type of bacterial development.

The policy of assembling milk in bulk in country creameries and transporting it to large centres of population for further treatment is favourable through the time factor involved to the development of these organisms. Many instances have come to light where counts of thermoduric bacteria were in excess of the maximum counts permitted for pasteurised milk immediately after both commercial and laboratory pasteurisation where recontamination after treatment was not a factor involved.

Essentials of Plant Design and Operation

The essentials of plant design and operation may be summarised as follows :

(1) Milk treated by the low temperature method requires to be heated to 145° F. and to be held at that temperature for precisely thirty minutes. High-temperature short-time treatment is dealt with later in this chapter.

(2) Heating must take place once only.

(3) Milk must be cooled rapidly to a temperature of not more than 55° F., and preferably lower.

(4) During the pre-heating and holding periods milk should be protected from contact with the atmosphere, and it is advisable that such protection should be also afforded when milk is being cooled.

(5) It is preferable to aerate milk during receiving and cooling unless this cannot be carried out without risk of contamination.

(6) Pumping should be reduced to a minimum, and such pumping as is essential should be carried out while the milk is warm. If it is essential that the milk should be pumped when cold, this process should never be performed *after* milk has passed over the cooler. Pipe-lines should be as short as possible to avoid unnecessary pumping.

(7) After cooling, agitation of milk should be reduced to a minimum.

(8) Any short-circuits in the process must be carefully avoided to prevent "unheld" milk gaining access to "held" milk, i.e. there should be no forward leakage. It is also essential that there should be no backward leakage, otherwise some milk may be treated twice in contravention of the Order. *One drop of infected milk may contaminate the entire volume.*

(9) Plant should be designed so that cleansing and sterilisation are rendered

easy. Corners and angles in tanks should be avoided and bends should be given as large a radius as possible to avoid any harbourage of dirt or bacteria, and also the accumulation of "milkstone." *Simplicity of arrangement with economy of space should be the keynote.*

(10) All parts of the apparatus should be constructed of highest quality metal, with the exception of the specially prepared rubber jointing material necessary to ensure soundness of joints. Permanent joints and seams should be ensured by means of autogenous welding. The use of solder is liable to cause electro-chemical action.

(11) Provision of reliable temperature-indicating *and* recording instruments constructed to show a variation of 0·5° F. is essential.

(12) The plant should work automatically, milk being untouched by hand from beginning to end of operations. This applies principally to large plants.

(13) The plant should be of sufficient capacity to treat the milk passing through without any need for speeding up the process to the detriment of the final product.

(14) Future expansion of business should receive consideration before a decision is arrived at regarding the capacity of any plant.

The whole equipment requires to be thoroughly co-ordinated and not merely an assortment or grouping of a number of different pieces of apparatus. The entire plant must be envisaged as a single unit, the choice and arrangement of its component parts conforming to this principle.

In short, a pasteurising plant should be inexpensive to maintain, reliable, efficient, simple in construction, and compact. It should be constructed of durable materials, easily operated and kept clean, and should be continuous in action.

Housing of the Plant

To provide for the satisfactory treatment of milk, suitable premises are required, the housing of plant being co-related to the design of apparatus. In many existing plants, insufficient space is a common defect, and it should always be remembered that the provision of adequate space is essential, together with an allowance for the future increase in apparatus as the volume of trade increases. In practice it is often found that this lack of space is due to want of thought in planning the lay-out rather than to actual restriction in available accommodation. The requirements of a building suitable for housing a pasteurising plant are :

(1) *Adequate floor space*, with a suitable allowance for future development. This is essential to afford ease of working, and in order to assist ventilation while preventing difficulties in management, cleansing and inspection. Lack of space is not so much due to inherent faults in the building but to want of thought in the lay-out of apparatus, while there is often a tendency to crowd the various pieces of apparatus together or locate them too near walls or ceiling.

(2) *Sufficient air space* and efficient ventilation. This is a prime essential on account of the high degree of humidity which is almost invariably found in premises where steam is employed for trade purposes. Excessive moisture prevents the maintenance of comfortable conditions, condensing on ceilings and dropping on to apparatus or gaining entrance to the milk. Probably the ideal system of ventilation is *controlled air conditioning*, which will maintain suitable temperatures in all weathers, restrict humidity, give adequate ventilation and which will be clean in action.

(3) *Suitable natural and artificial lighting.* This is extremely important in order that proper supervision may be given to the plant, together with facilities for inspection of all processes and recording instruments. Good lighting assists in the maintenance of hygienic conditions and accidents to employees are obviated. Window area should not be less than 10 per cent. of floor space. As regards artificial lighting, the following standards should be maintained :

(*a*) Thirty to thirty-five foot candles during cleansing operations.

(*b*) Fifteen to twenty foot candles while processing is in progress.
(*c*) Localised lighting in the vicinity of washing and bottling machines and where temperature recorders and thermometers are installed.

(4) *Freedom from noxious odours and effluvia.* This is mainly a question of efficient ventilation and cleansing.

(5) A non-slippery *floor* of hard impervious material, well drained and easily cleansed ; *walls*, with hard impervious internal surfaces, preferably of glazed brick ; and a satisfactory *roof*, free from dust traps, giving adequate lighting and ventilation, if required.

The Pasteurising Plant

A complete plant for the treatment of milk by pasteurisation is made up as follows :

(1) Tipping Tanks.
(2) Pumps.
(3) Receiving or Storage Tanks.
(4) Heater.
(5) Filters.
(6) Holders.
(7) Cooler.
(8) Pipe-lines.

(1) **Tipping Tanks.** These tanks are found in the majority of dairies, and into them raw milk is tipped on receipt at the premises. The choice of metal for these tanks as for other portions of the plant is important, and it is essential that adequate protection should be afforded to the milk. Stainless or chrome-nickel steels are ideal materials for the purpose, as they resist

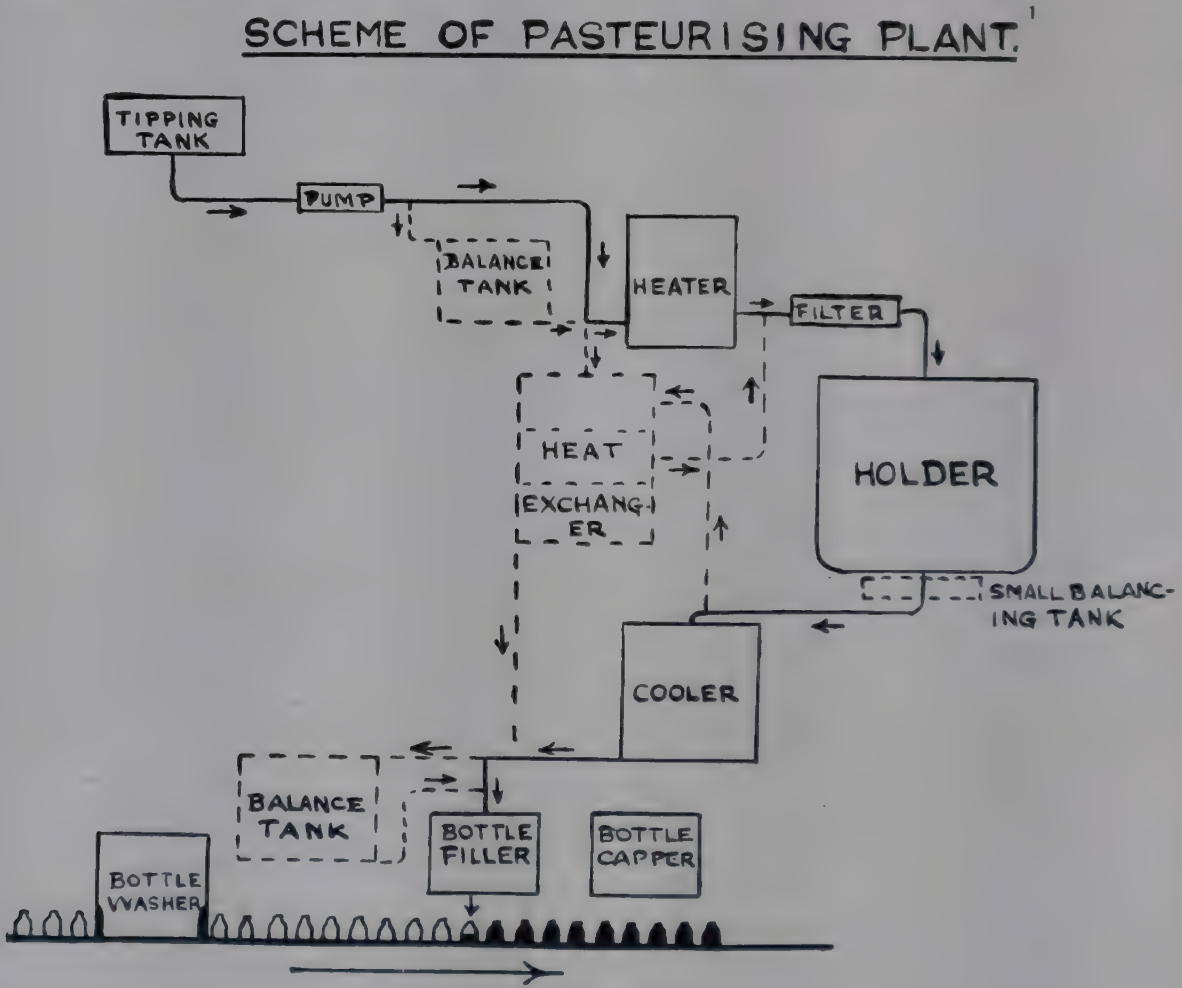

SCHEME OF PASTEURISING PLANT.[1]
TIPPING TANK
PUMP
BALANCE TANK
HEATER
FILTER
HEAT EXCHANGER
HOLDER
SMALL BALANCING TANK
COOLER
BALANCE TANK
BOTTLE FILLER
BOTTLE CAPPER
BOTTLE WASHER

FIG. 156.

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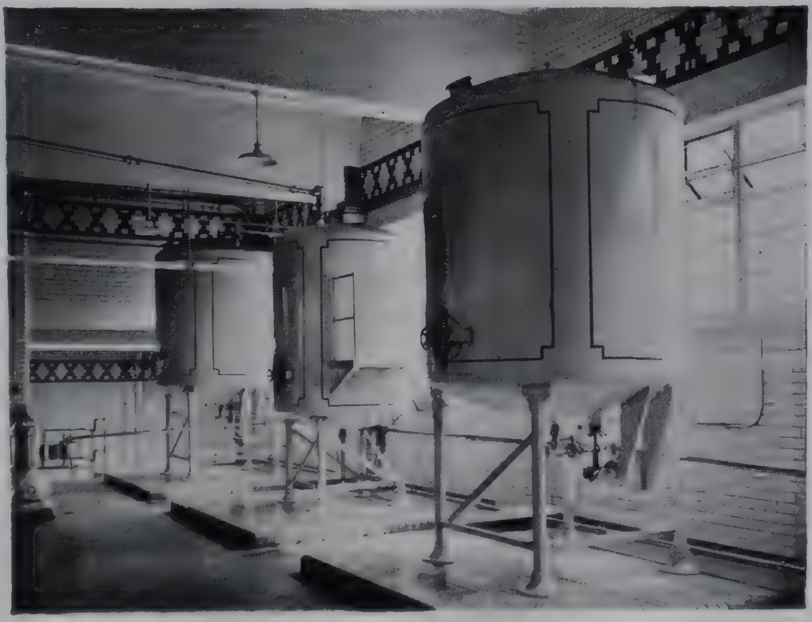
[1] Reproduced by permission of the Controller of His Majesty's Stationery Office from Reports on Public Health and Medical Subjects, No. 77, of the Ministry of Health—" The Supervision of Milk Pasteurising Plants," 1935.

the corrosive action of milk and are readily cleansed. As the tanks are usually situated where dust and dirt from the open yard may come into contact with the milk, they are generally provided with *metal splash hoods* and removable covers, which can be raised to allow milk to enter. *Strainers* are sometimes fitted to remove coarse particles of extraneous matter, such as straw, hairs, and particles of dung, while *can drainage racks*, if provided, should be readily detachable for cleansing purposes. In many cases tanks are fitted with *agitators* to secure homogeneity of the milk, but these should be designed so that there is no interference with cleansing operations. These tanks are generally situated at ground level, milk being pumped either to receiving tanks or direct to the heater. They should not be regarded as essential, but in very many instances their employment is necessary. They often serve the double purpose of receiving and weighing tanks, so that a check can be kept upon the quantity of milk received from individual producers.

(2) **Pumps.** When tipping tanks are provided, some form of pump, preferably of the rotary type in order to cause less damage to the milk, is essential in order to raise the liquid to a sufficient height to allow of gravitation through the plant or to propel it to the heater. The function of a pump, if no receiving tanks are provided, may be performed by a *centrifugal clarifier* which draws milk from the tipping tank. Pumps may produce gross contamination, particularly if improperly cleansed, and it is essential that no " glands " or " stuffing boxes " should come into contact with the milk. They should be constructed of stainless steel in order to prevent any chance of metallic contamination arising, although, if at all possible, the design of the plant should render their employment unnecessary. Badly designed pumps are one of the causes of frothing or foaming, which may seriously interfere with efficient pasteurisation. The cream-line may also be affected. Pumping should be reduced to a minimum, and the operation, where necessary, should be carried out, if possible, when milk is in a warm condition. A plant in which it is necessary to pump milk after cooling is badly planned.

(3) **Receiving or Storage Tanks.** Many large dairies install large-capacity, insulated, receiving tanks in order to store milk until required for use so that



By courtesy of Enamelled Metal Products Corporation (1933), *Ltd*

FIG. 157. " Pfaudler " Glass-lined Steel Milk Storage Tanks any interruption of the process may be avoided, all milk being preferably cooled before it is allowed to pass for storage. These are situated at high level well above the remainder of the apparatus if gravity flow is in use, or at floor-level if the vacuum and compressed-air system is installed. Milk is pumped direct from rail or road tank wagons and is carried from these tanks through the various processes. Milk may also be pumped from a tipping tank into one of the receiving tanks. Such tanks should preferably be constructed of stainless or chrome-nickel steels or provided with glass-enamelled internal surfaces. These materials facilitate cleansing, and all tanks should be provided with suitable means of access for cleansing purposes. Provision is often made for agitation of the milk during storage, but agitating gear must be well designed, otherwise cleansing may be rendered difficult.

Tanks for receiving milk as it leaves the holding compartments are sometimes found. They are usually termed "*balancing tanks*," their purpose being to equalise the milk before it passes to cooling and bottling apparatus. While such tanks cannot be considered desirable, they should be provided with suitable covers, and any foam which occurs should not be able to find its way back from the cover into the milk. "Balancing tanks" may be employed for storing cooled milk after pasteurisation in order to ensure that bottle-filling machines are kept continually in operation. This practice cannot be considered satisfactory as plant should be designed so that all processing is continuous.

(4) **Heater.** The pre-heating of milk before it enters the holding compartments is equally as important as subsequent cooling. With the use of the pre-heater, the need for precision working commences, and it is essential that such apparatus should deliver *all* the milk to the holders at a temperature above the legal minimum but below the legal maximum, this being usually between 1° to 2° F. above the minimum required. This is necessary in order to counteract loss of heat which may occur in the passage of milk to the holders. Both pre-heating and holding may be carried out in the same vessel, but this is not advisable in any except the smallest plants, since constant supervision is necessary. The heater is used to raise the temperature of milk above the legal minimum but below the legal maximum. Badly designed apparatus will readily cause uneven heating. Separate heaters are not often installed, although there are several types, as follows:

(*a*) Apparatus similar to an ordinary cooler with hot water running through instead of cold, milk passing over the outer surface. This type possesses all the disadvantages of an ordinary cooler so far as contamination of the milk from the atmosphere is concerned, while the surfaces are difficult to cleanse and sterilise. When such apparatus is employed, particular attention must be paid to the joints where the tubes enter the tube plates, as a failure at this point would be followed by re-contamination of the milk.

(*b*) Plant designed to revolve milk rapidly around the heated inner surface of a conical vessel, the milk being thrown by centrifugal force over the upper edge of the cone. The time taken for milk to rise from the bottom of the cone, to which position it is constantly fed, until it is thrown over the lip, is sufficient to raise it to the desired temperature. This type of apparatus usually causes the formation of foam.

(*c*) A further type, in which milk passes through the annular space between an inner and an outer tube. These tubes are generally surrounded by hot water, which acts as the heating agent. The employment of hot water for this purpose prevents overheating of milk

It is now the accepted practice to combine heater and cooler and to make use of the principle of "heat exchange," in which hot pasteurised milk passes through an apparatus, giving up its heat to cold milk moving forward for treatment. Although further heating and cooling of the raw and pasteurised milk has to be arranged, it is possible to effect a great saving in fuel costs by this method. The three usual types of *combined pre-heater and cooler* are :

(*a*) *A modified form of ordinary cooler.* Milk to be cooled passes over the external surface and that to be heated passes through the tubes. This apparatus possesses all the disadvantages of the ordinary cooler as regards contamination from the atmosphere, while the internal surfaces of the tubes are difficult to cleanse and sterilise efficiently. Particular attention must be paid to the joints where the tubes enter the tube plates, since a failure at this point would be followed by re-contamination of the milk.

(*b*) A second type known as the *double-tube heat exchanger.* This consists of a series of concentric tubes suitably interconnected. Milk to be heated flows through the annular space provided between the two concentric tubes, and milk to be cooled flows through the inner tube. This type of heat exchanger gives satisfactory results, and milk is not exposed to the atmosphere. The apparatus requires sufficient space, as it consists of lengthy tubes, while extra room must be provided for withdrawal of the inner tubes for cleansing purposes. Cleansing is a problem, while considerable difficulty may be experienced in maintaining the joints. If such joints are of satisfactory design, the only way in which milk may be contaminated is by perforation of one of the tubes.

Both the above types of heat exchangers require the addition of special sections for final heating and cooling of milk.

(*c*) A third type, probably the most satisfactory of all, is known as the *plate heat exchanger.* This consists of a series of grooved gun-metal or stainless steel plates, the liquid to be heated or cooled flowing on one side and the heating or cooling medium on the other. Metal cones are substituted for plates in some types of apparatus. The plates are tightly bolted together and may be readily uncoupled for cleansing purposes. Machines are generally built in four sections, as follows :

(1) *Regenerative Section.* In this section raw milk is heated by hot milk leaving the holder after treatment.

(2) *Heating Section.* Warm milk is here further heated by hot water to a temperature of 146°–147° F.

(3) *Water-cooling Section.* Secondary cooling is supplied here.

(4) *Brine-cooling Section.* Final cooling of milk to 40° F. is carried out in this section.

After preliminary heating in the regenerative section, milk passes to the heating section. From this section it flows to the holder via the filter or clarifier and, after treatment, returns to the regenerator, from which it passes through the water- and brine-cooling sections of the apparatus. In this type of heat exchanger, a perforated plate is the only likely cause of re-contamination of milk.

The essentials of a satisfactory heating system are :

(*a*) All milk treated should be raised to a temperature slightly above the legal minimum.

(*b*) No portion of milk should be raised above the legal maximum.

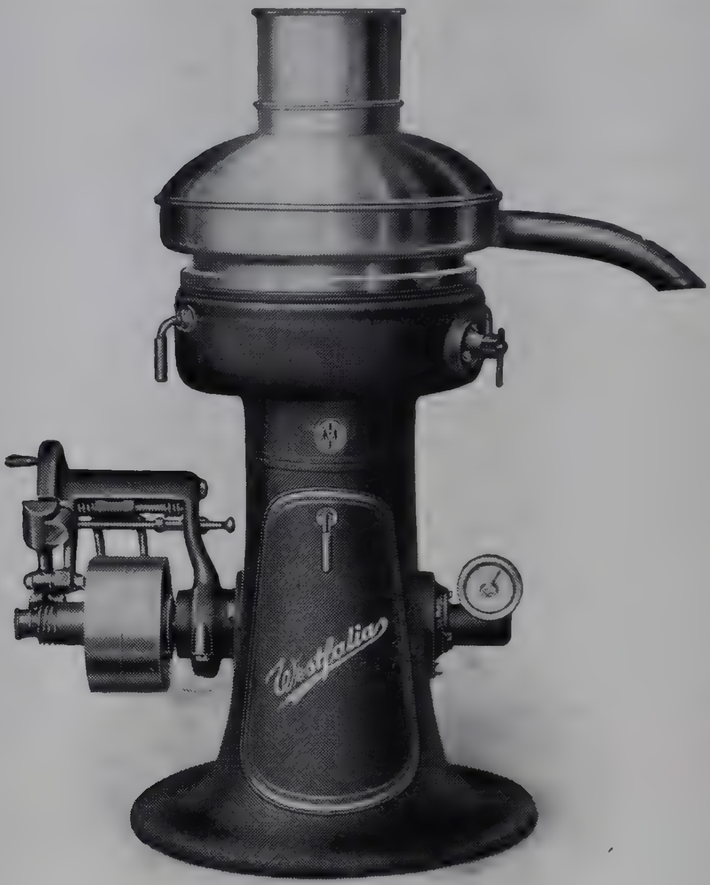
(*c*) Complete separation of raw from treated milk and from hot water used for heating purposes should be effected.

(*d*) The apparatus should permit of easy cleansing and sterilisation.

An *automatic recording thermometer* should always be fitted at the outlet of the heater to ensure that all milk passing through to the filter and holder will be raised to a sufficient temperature. Any drop in temperature, which may amount to two or three degrees, can thus be detected. If this occurs or if the temperature is very near to 145° F. a careful check of the pasteurised milk temperature should be made.

(5) **Filters.** Although some types of filter may cause loss of heat, these are generally fitted so that milk is treated after the first stage of heating, as the liquid can be filtered much more easily in its warm state, while the cream-line is less disturbed. Filtration is necessary to remove any dirt or slime which may be contained in milk the removal of such impurities being carried out by means of a *cloth filter* or by the use of a *clarifier*.

Some distributors use a *centifugal milk clarifier*, which combines the functions of heater, cleaner and milk pump. These machines, which work on the principle of a cream separator, extract visible dirt, epithelial cells, and slime from milk by centrifugal force. They operate very efficiently at 2,000 revolutions per minute if the milk is pre-heated, but their churning action tends to alter the texture of milk and increases foaming. The effect on the cream line varies according to temperature, being little altered in this respect at temperatures under 40° F., but being definitely affected at temperatures above 100° F. For these reasons they are being rapidly replaced by cloth filters, as previously mentioned. Clarifiers which assist in maintaining the temperature of milk are always fixed between the heater and the holder in a similar position to that of the cloth filter, but, when used for cleansing purposes only, they are occasionally fitted in front of the heater.



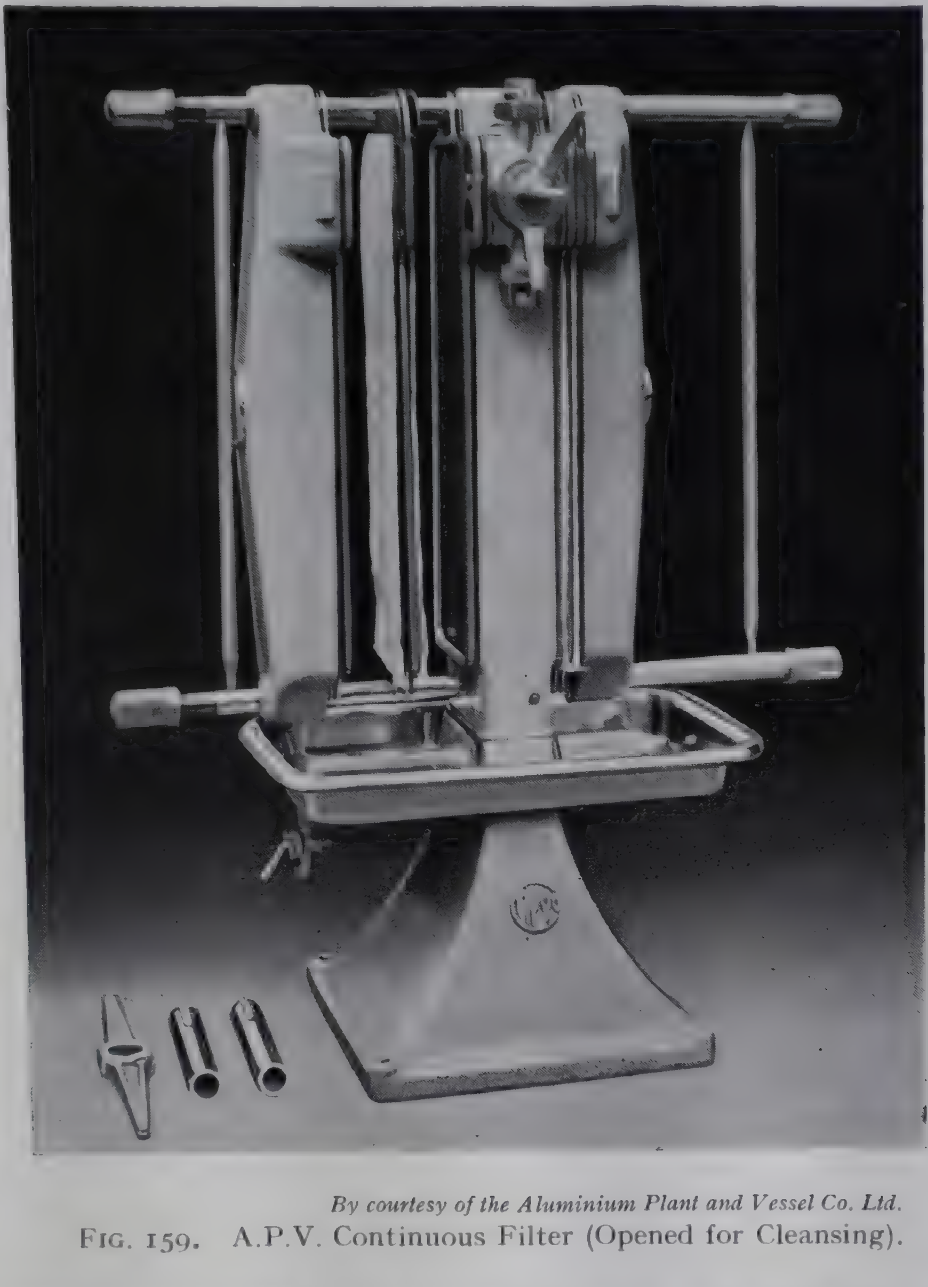
By courtesy of the Dairy Outfit Co., Ltd.

FIG. 158. Power Clarifier.

The filters in general use are of the *enclosed* type and are so arranged that the filtering media can be changed without interruption of the process. Enclosed filters lend themselves admirably to the "closed circuit" method now so popular, as this method ensures that milk during all stages of processing is not in contact with air, thus preventing any risk of airborne contamination. They are constructed with a view to easy dismantling and are also arranged to prevent any unfiltered milk passing through or any waste when the filtering medium is changed. They are usually provided with a hot-water jacket in order to maintain the temperature of milk during its passage through the apparatus and to ensure that it reaches the holder at a sufficiently high temperature. The filtering medium is usually cotton cloth which possesses one "fluffy" side which is placed so that it faces the flow of milk. This fluff is driven into the cloth by milk passing through and effects filtration. The medium is usually supported on a perforated metal disc, and care must be taken to ensure that the pressure of milk does not exceed 10 to 12 lb. per sq. inch or damage to the filtering medium will occur, when filtration will be unsatisfactory.

This pressure is sometimes increased when slow filtration due to chokage or insufficient filtering surface is experienced or when attempts are made to filter cold milk.

There is no doubt that the cloth filter is quite as efficient as the clarifier. It possesses the further advantage of causing no interference with the texture of milk. Cloth filters are more economical than the centrifugal clarifier, as this apparatus requires a large amount of power, while the initial cost and replacements considerably raise the expense incurred.



By courtesy of the Aluminium Plant and Vessel Co. Ltd.

FIG. 159. A.P.V. Continuous Filter (Opened for Cleansing).

Filtering cloths and other filtration media require to be frequently changed during processing operations. A supply of sterile cloths should be readily available in a protected container. Some plants make use of several filters in order to prevent delay in treatment when the cloths are changed. Filter cloths should be used once only, after which they may be washed, dried and used for cleansing purposes.

(6) **Holders.** Accurate working of the holder or holders is essential, as time and temperature must be strictly adhered to if the process is to be

efficient from a public health point of view and a commercial success. This apparatus is the most vital part of the plant, as upon the success of treatment of the milk at this point depends the safety of the entire method.

The holder may either consist of a single tank, or may be divided into a series of compartments, each compartment having a separate inlet and outlet. There should be complete separation of the various compartments both during the holding period and while filling or discharging, and any chance of overflow from one compartment to another should be carefully guarded against. Each compartment must be covered to protect milk from contamination during treatment, to prevent heat losses and oxidation of the liquid, and covers should be designed so as to prevent the formation of milk pools on their upper surfaces. Milk pre-heated to the required temperature enters the holder, where it is held for exactly thirty minutes and then discharged. Accurate working of the holder or its several compartments is essential as time and temperature are of vital importance and must be strictly observed if processing is to be efficient; this requirement cannot be too often emphasised. The operations of filling and discharging the holder or its separate compartments are, except when the vacuum system is employed, controlled by valves which may be either hand or mechanically operated. Mechanical operations for this purpose are to be recommended, and these are generally controlled by means of an automatic timing system. In large plants, the complete cycle of filling, holding, and discharging occupies approximately forty-five to sixty minutes, the time varying according to the number of compartments in the holder. A time interval of seven and a half to fifteen minutes is allowed for each compartment to fill or discharge. Automatic control is always preferable, as this prevents the occurrence of errors which may arise following carelessness on the part of operators. Such control should, if possible, be fool-proof and its accuracy frequently checked, as no mechanical device, however perfect, can be relied upon to remain accurate for all time. Milk may be fed into the holder from the upper or lower end, and, after treatment, may leave in either fashion. The method of filling and discharging depends to a great extent upon the design of valve timing employed, but, if milk enters the tank at the upper end, the inlet pipe should be carried down towards the lower extremity of the holder as a prevention against the formation of foam. Foaming of milk should be impossible in a well-designed plant, particularly as the temperature of foam may be ten to fifteen degrees below the temperature required for satisfactory treatment. If foaming is allowed to occur, milk will not be properly held, receiving extra exposure to the atmosphere, which favours the destruction of certain vitamins due to oxidation and impairing the flavour of the milk. Plant design should ensure that foam which is present on the surface of milk when in the holder compartment should be maintained at correct pasteurising temperature. Surface cooling may be obviated by means of *air heaters* fixed in the compartments above the surface of the milk. These will prevent loss of heat through covers being left off accidentally, through lack of suitable agitation or on account of absence of insulation of covers. Experiments have shown that air above the milk surface may be several degrees cooler than the liquid itself and, in the United States of America, it is compulsory to fit such heaters. These usually consist of perforated steam distributor pipes through which controlled, dry steam is discharged. This steam maintains the air temperature at a sufficiently high level so that no surface cooling takes place. The outlet valve is generally placed at the lower end of the tank, but can be placed above, provided the compartments are designed to ensure complete exhaustion of all milk. If outlet valves are placed above, the same mechanical timing can be employed for outlet as for inlet valves, while the timing gear is more easily accessible for adjustment.

If valves are not efficient, leakage of treated or partly-treated milk becomes possible, with probable unsatisfactory results to the final product. It is generally impossible for milk to leak backwards from the holder owing to gravitation, but, if such leakage does occur, it is unimportant, provided provision is made to ensure that such milk runs to waste and does not return for re-pasteurisation in direct contravention of the Order. It is particularly important that there should be no forward leakage in order that "unheld" milk does not gain access to milk which has been treated. Valve gearing is usually mechanical and of great precision, the valves opening and closing to a prearranged schedule. If standard alternating current was available throughout the country, valve-operating gear could be controlled in a similar manner to an electric clock. As all types of timing systems require to be accurate, it is necessary to again emphasise that this accuracy requires periodical checking. Valves should be manufactured of stainless steel, no glands or stuffing boxes coming into contact with milk. Seatings are generally metal to metal, but, if any packing of valves is necessary, care should be taken to ensure that no harbourage for bacteria is provided. There should be no connection between inlet and outlet pipe-lines, and the inlet valve of one compartment should never feed the inlet valve of another, following wear of the valve seatings. Even with some reputable makes of plant, the prevention of re-contamination of milk is not complete owing to unsatisfactory valve design. Valve seatings should be periodically inspected to ensure tightness and freedom from drips and care should be taken to ensure that it is impossible for any drips to come into contact with treated milk.

It is necessary to maintain heat for the specified period of thirty minutes and to guard against any drop in temperature, whether milk is pre-heated before holding or is heated in the holder. This difficulty of temperature drop is overcome in a variety of ways and all types of plant make provision for heat-maintenance. In many cases the jacket surrounding the holder is heated prior to the entrance of milk. The water jacket then remains filled with hot water during the time milk is in the holder and no further heating is attempted, There is, of course, a fall in the water temperature during the holding period and, to compensate for this, the temperature of milk is raised to the maximum allowed. This method of heat-maintenance is crude and particularly objectionable owing to damage which milk may receive through overheating, while there is no guarantee that the liquid will be retained at the specified temperature for the entire period. In some plants, hot water is used as the heating medium, and, by means of proper thermostatic control which ensures efficient heat maintenance, milk is retained throughout at a temperature of 145° F. The methods employed have already been detailed on pages 272 to 279. With this system, it is essential to provide a sufficient quantity of hot water for heating purposes in order to ensure that interchange of heat is complete. The most general type of heat-maintenance in use is that provided by complete insulation of the holder or its compartments, either by means of air, by creating a vacuum in the jacket surrounding the tanks, or by means of cork or asbestos lagging.

Many makers claim excellent results from this method, but insulation, whatever type is employed, must be highly efficient. However suitable it may be, it is doubtful whether the methods employed are sufficient to prevent some loss of heat. The efficiency of insulation depends upon the method used, and, if solid material is employed, the way in which this is packed around the holder. It is very important that *all* milk should be held within the insulated zone in order to protect it from undue loss of heat. In some types of holders covers are not insulated, when, owing to surface cooling, all milk may not be held in a satisfactory manner as prescribed by the Order. The insulation of this part of the apparatus is extremely important, and if the whole of the cover is not properly insulated, particular attention should be paid to the temperature of outgoing milk.

Agitation during holding has been condemned by many authorities on account of the fact that foaming may be increased by incorrectly designed agitators. In all plants, however, loss of heat may be greater at one point than at another, and agitation, provided it is efficiently carried out, overcomes this difficulty by ensuring that all milk will be properly heated and kept at the required temperature. Again, if some means of agitation is not provided, cream will readily rise to the surface. As it is not advisable to have balancing tanks between holder and cooler owing to damage to cream-line and on account of the possibility of re-contamination, milk drawn first from the holder would, in the absence of agitation, be deficient in fat when bottled. There can be no objection to the use of agitation if the paddles move at the correct speed of not more than six complete swings per minute, and it may be noted that the process is now compulsory in the United States.

Temperature control is again of the utmost importance, and both a recording and indicating thermometer should be placed at the combined outlets of the holders. These instruments should be placed in a good light, where they may easily be inspected. When " Batch " holders are employed, a recording and indicating thermometer should be provided for each tank.

(7) **Cooler.** Cooling exerts a considerable effect upon the cream-line of milk so treated. Tests carried out by the Research Department of the Creamery Package Company illustrate this effect and may be summarised as follows :

> " Milk from surface coolers (open to light and free to aerate) in six tests showed an average increase in cream volume of 3 per cent. to 4·8 per cent. over milk at pasteurising temperature before cooling. In contrast to this, milk from enclosed coolers showed a decrease in volume of 3·1 per cent. to 4·8 per cent., giving a difference in favour of the open-type cooler of 6·1 per cent. to 9·6 per cent."

From the foregoing it would appear that, provided milk can be adequately protected from contamination during cooling, an *open-type* cooler will provide a more satisfactory cream-line.

From a public health point of view, however, cream-line is not vitally important, it being more essential to provide proper protection against contamination. Independent coolers are still to be seen in many dairies, and the old type of so-called " *surface cooler* " is probably the commonest. Cooling with an apparatus of this type is primarily carried out by means of water followed by brine or other methods of refrigeration, principally chilled water. This method of treatment possesses the following disadvantages :

(*a*) A large amount of space is rebuired.

(*b*) Loss of milk occurs by evaporation.

(*c*) Freezing of milk takes place on the lower tubes (this is generally due to bad management).

(*d*) Exposure of milk to air may give rise to re-contamination.

The water section of the cooler should be so balanced that the temperature of the milk is reduced to approximately 75° F., after which, by means of brine or chilled water, this temperature can be further reduced to 40° F. Surface-type coolers should always be protected from dust and dirt by means of a well-fitting metal shield, and should be designed to allow a thin film of milk to pass over, in order to ensure that interchange of heat is completely uniform and that the heat is extracted from milk in an economic manner and within correct temperature limits.

When a *separate cooler* is used, it is necessary that this should be open to light and air, although protected from contamination. The effect of light and particularly sunlight is important, and it is extremely desirable to aerate milk during the cooling process. It must always be remembered that milk after pasteurisation has lost the greater portion of its initial bacterial content and is therefore extremely liable to re-contamination if not carefully handled. To allow of aeration and exposure of milk to light, a new type of cooler of the " surface type " has been devised. This apparatus is enclosed in a glass case, to which a supply of purified air has access.

A special cabinet type of surface cooler has been introduced into this country from America within the last few years, consisting of a number of short coolers mounted in parallel on rails and totally enclosed within a cabinet. Each section can be extracted in turn for cleansing purposes. This cooler is more compact than the usual type of " surface cooler," occupies less floor space than that normally required by this type of apparatus, cooling being effected by chilled water instead of brine.

The most common method of cooling milk now employed in large dairies makes use of the " *heat exchanger* " previously described, in which a primary cooling of pasteurised milk after leaving the holder is given by untreated milk passing forward for processing. The temperature of the partly cooled milk is further reduced by water, followed by chilled water or brine.

It is important to remember that when fat globules have collected in cooling, subsequent agitation of milk should be avoided as far as possible. Whatever type of cooler is employed there should be complete protection from any chance of re-contamination or mixture with the cooling medium. Separate coolers must always be employed for raw and treated milk, while the outlet from the cooler to the bottling machine should be provided with the usual types of temperature indicating and recording apparatus. If bacterial growth in treated milk is to be entirely inhibited, it should always be cooled to a temperature of 40° F. or below.

(8) **Pipe-lines.** Pipe-lines are extremely important units and should be kept as short as possible so that unnecessary pumping is avoided, in order to reduce any possibility of heat losses and to facilitate cleansing operations. There should be no " short-circuits," " dead-ends " or " cold pockets " in pipe-lines, where milk may be retained outside proper temperature limits and which are difficult to cleanse. This fault is generally due to unsatisfactory lay-out and can be avoided by careful planning. Pipe-lines should be easy to dismantle and cleanse and be manufactured from metals able to withstand constant cleansing and sterilisation. Separate pipe-lines

for raw and pasteurised milks are essential to prevent any re-contamination of the treated product, and they must be capable of being broken up into short sections for cleansing purposes.

Bottling

On leaving the cooler milk passes to a bottle-filling and capping machine. These processes have already been described and it will be sufficient to state that, with pasteurised milk, bottling operations should be carried out with a minimum disturbance of the liquid and with an absence of foaming. On no account should milk be pumped.

Installation of the Plant

Before any plant can be installed, certain points require consideration. These are :

(1) *Quantity of milk to be treated.* The size of plant required primarily depends upon the number of gallons of milk to be handled, although, before a decision is actually made, due consideration should be given to probable increase in business.

(2) *Method of installation.* It may be found more convenient to install two small holders in place of one large tank. Here again much depends upon the space at the disposal of the proprietor.

(3) *Number of times pasteurisation is to be carried out per day.* Milk may be treated in one batch, in morning or evening batches, or even three or more times daily. Upon this depends the number of holders required. The needs of the small distributor would be adequately satisfied with one or two " Batch " holders, whereas the large producer would require several large holders.

(4) *Method of cooling adopted.* In this connection it must be remembered that those persons using certain makes of " Batch " pasteurisers may, if they so desire, supply a primary cooling to milk while in holder.

(5) *Type of plant.* If the distributor wishes to produce pasteurised milk to be sold under that designation by licence from a local authority, it will be necessary to install one of the many types of approved low or high-temperature short-time plant. On the other hand, if the only object is to improve the keeping quality of milk from a commercial aspect, he can, if he wishes, install any type of plant he desires. It should be borne in mind, however, that if pasteurisation becomes compulsory, many systems of treatment are unlikely to receive the approval of a licensing authority.

Plants for the Small Distributor

It has often been stated by opponents of pasteurisation that, if this a method became compulsory, many small distributors would be forced out of business. This is not necessarily so, as it is possible to provide an efficient plant suitable for the small distributor which is both reasonable in cost and economical in operation. (The term " small distributor " in this instance is employed to denote a dairyman whose total output of milk does not exceed 300 gallons per day.)

Such persons should always install " Batch " pasteurisers which provide a method of treatment quite suitable for compliance with the requirements of the Milk (Special Designations) Order, 1936. It is possible to obtain apparatus of this type which can be arranged to give continuity of action and which will treat small quantities of milk. Generally speaking, the " Batch " pasteuriser is both foolproof and economical, and is to be recommended. So much has been said and written about automatic plant that this system is often overlooked, but if its modern design is studied, it will be seen that this apparatus is not secondary but equal, in a different way, to the larger automatic plants. For large outputs it will be agreed that plants of greater capacity which are automatic in action are required, but for small or even medium outputs, the capital necessary for installation is not excessive and is more likely to be available. Dairy engineers have expended considerable time, energy and capital to improve the design of "Batch" pasteurisers so that no fault can be found with present-day apparatus of this type by the severest critic of the process. Further, these plants have been designed to meet the exacting requirements of the Statutory Orders. "Batch" pasteurisers can, if desired, be arranged to give continuous output by installing holders in series or in a battery. Single-vessel pasteurisers may be purchased with capacities varying from 15 to 100 gallons of milk. It is, however, always preferable to have two 50-gallon vessels rather than one 100-gallon holder.

In dealing with milk in quantities above 100 gallons per day, it is advisable to have a series of pasteurising vessels, for the following reasons :

(1) The heating surface of two separate holders is greater than that of one large vessel of similar capacity. This allows milk to be heated more rapidly.

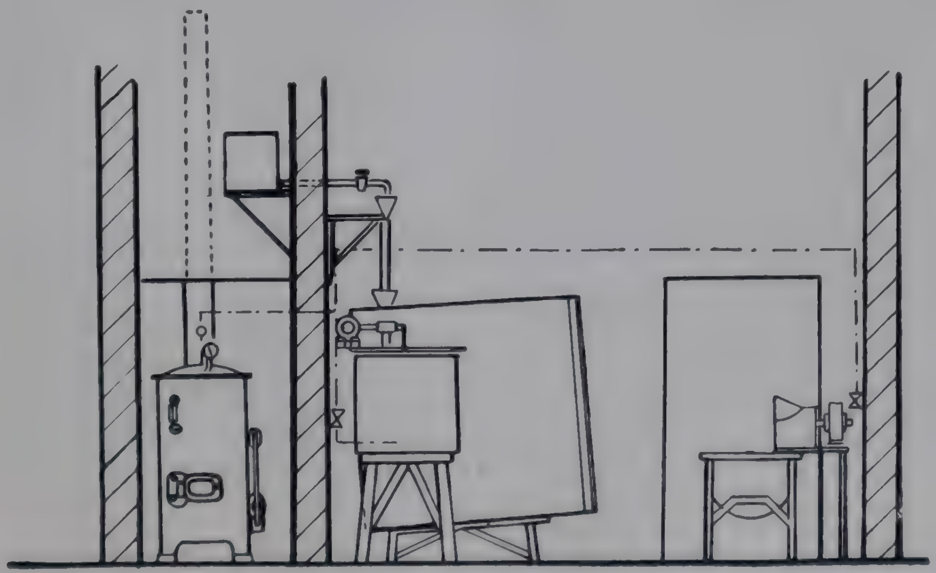
(2) As it takes some time to fill and discharge the vessels, the first holder can be put into operation immediately it has been filled, during the filling of the second or subsequent vessels. Three tanks ensure that very little time elapses after the last vessel is filled before the holding period in the first vessel is completed ; while, if five tanks are installed, a continuous processing can be carried out.

(3) It is easier to obtain a consistent temperature when dealing with small batches of milk than is the case when such milk is treated in bulk.

The figures in Table 15 below, supplied by Messrs. Aveling-Barford, Ltd.,

TABLE 15.

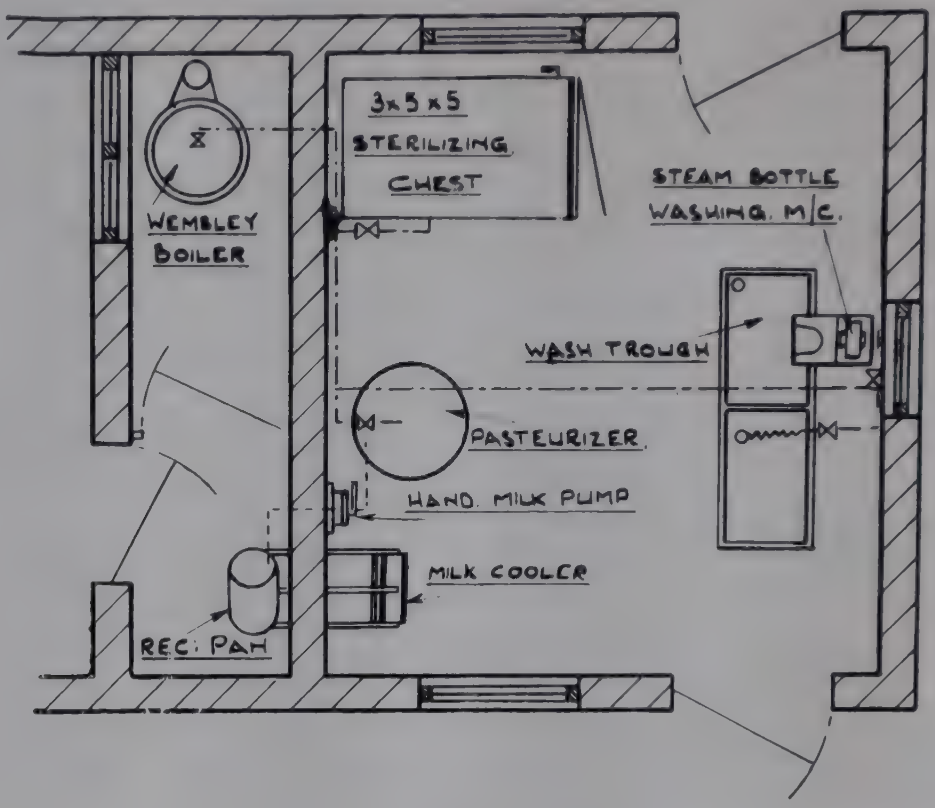
Gallons to be Treated Daily.	Pasteurised in		
	One Batch.	Two Batches.	Three Batches.
	Gallons.	Gallons.	Gallons.
100 . .	2–50	50	40
150 . .	3–50	80	50
200 . .	4–50	3–50	2–50
250 . .	5–50	3–50	2–50
300 . .	6–50	3–50	2–50



By courtesy of Aveling-Barford, Ltd.

FIG. 160. Section. Small Pasteurising Installation. Holder at Floor Level.

relate to the installation of their "Econom" pasteuriser, but may be quite well taken as representative of all types of "Batch" apparatus. They

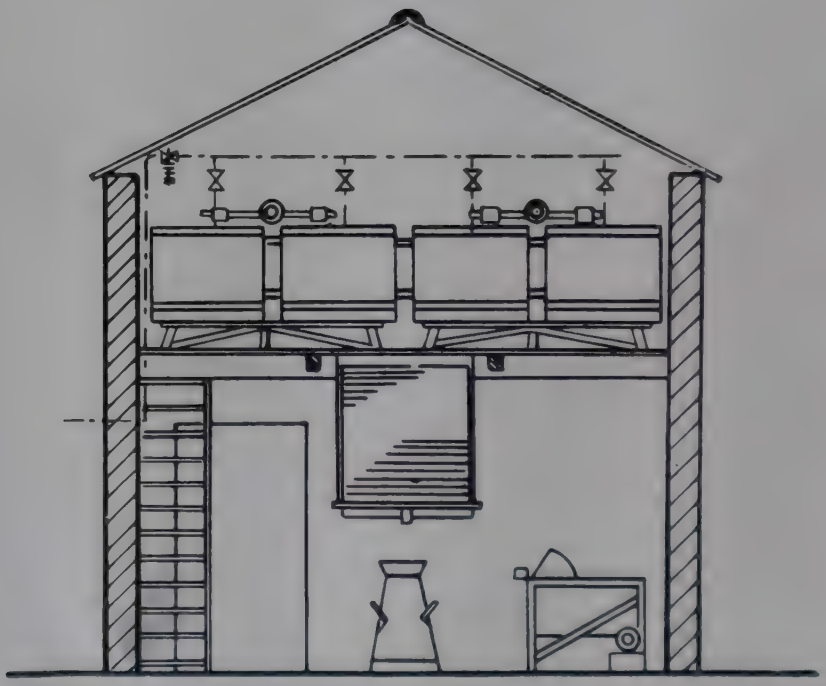

3x5x5
STERILIZING
CHEST
WEMBLEY
BOILER
STEAM BOTTLE
WASHING. M/C.
WASH TROUGH
PASTEURIZER
HAND. MILK PUMP
MILK COOLER
REC: PAN

By courtesy of Aveling-Barford, Ltd.

FIG. 161. Plan of Small Pasteurising Installation.

illustrate the numbers and sizes of holders required for treating quantities of milk ranging from 100 to 300 gallons per day.

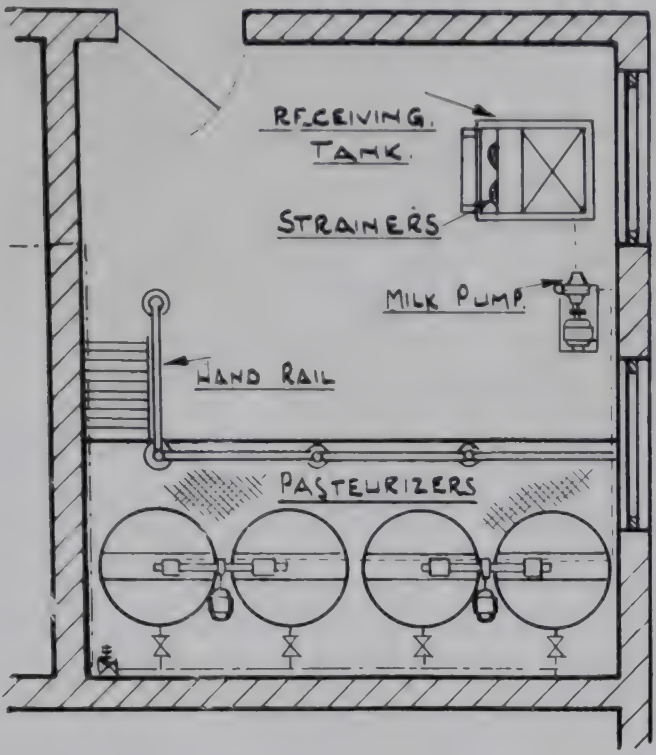
The "Econom" pasteuriser is one of many types of plant to be



By courtesy of Aveling-Barford, Ltd.

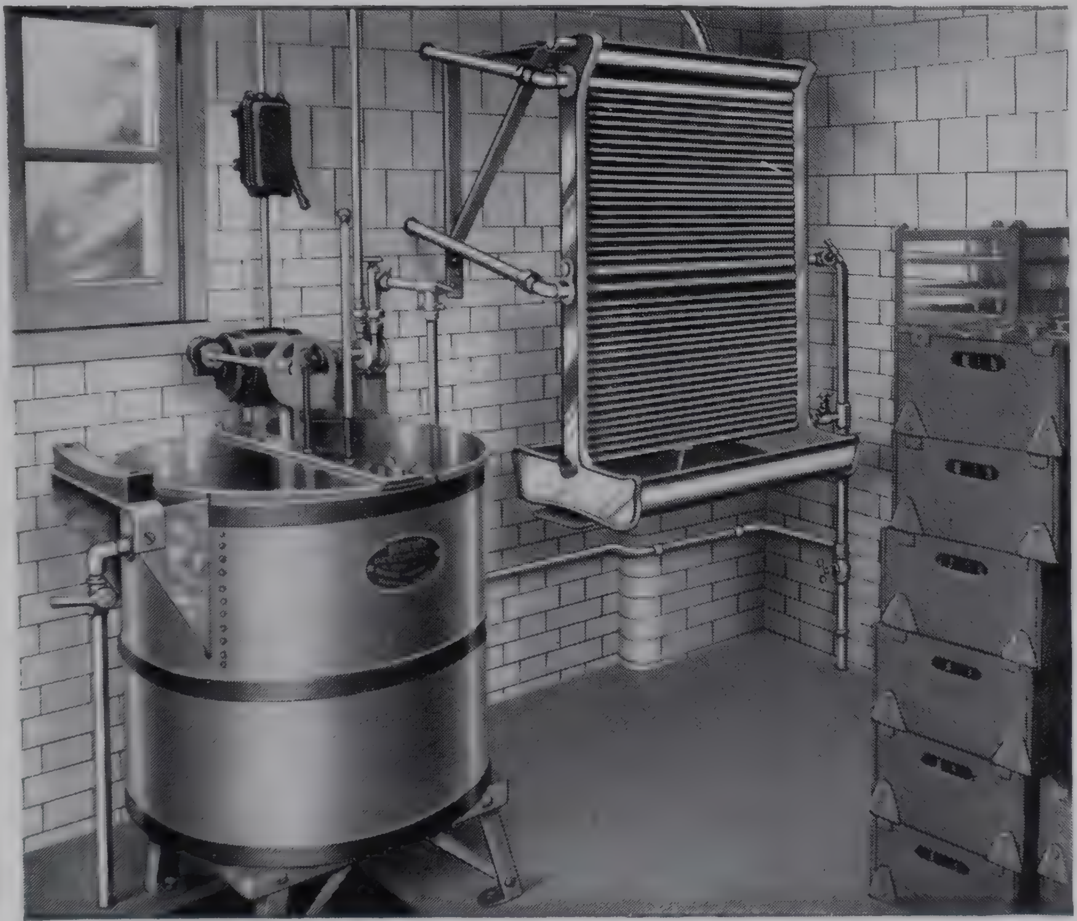
FIG. 162. Section. Small Pasteurising Installation. Holders Mounted at High Level.

obtained which, while complying with official requirements as to positive holding, are reasonable in cost and economical to maintain, being therefore essentially suitable for the small distributor. Such apparatus can be purchased by the distributor in separate units, while extensions may be easily and economically carried out as required, provided sufficient room has been allowed for expansion. This type of plant may be installed in different ways, as follows :


RECEIVING. TANK.
STRAINERS
MILK PUMP.
HAND RAIL
PASTEURIZERS

By courtesy of Aveling-Barford, Ltd.

FIG. 163. Plan of Small Pasteurising Installation.



By courtesy of Aveling-Barford, Ltd.

FIG. 164. Single " Econom " Pasteuriser with Cooler.

(1) The holder may be fitted on a stand with the outlet 2 feet 6 inches above floor-level, so that it may be emptied by means of a bucket. This method should only be adopted in the smallest dairies, as, when fixed in such a manner, considerable handling of milk is involved. Milk is strained into the holder by means of a removable strainer fixed into the lid. After processing has been completed, the milk is drawn off into a can or bucket and emptied into a receiving tank fitted over the cooler.

(2) The apparatus may be fitted approximately 1 foot above floor-level, milk being poured in through a strainer as before. After treatment it is pumped into a receiving tank, from which it gravitates over the cooler. A pipe-line filter may be fitted in the delivery pipe leading to the receiving tank, although this is not advisable.

(3) The pasteuriser may be fitted on a platform well above the general floor-level if the building provides sufficient internal height to allow this to be done. This method of installation is to be recommended as milk, after treatment, flows by gravity over the cooler and pumping is not required. Milk is poured into a receiving tank at floor-level and is pumped into holders situated on the platform, passing through a filter fitted in the pipe-line. After treatment the milk gravitates over a cooler. The platform should be provided with suitable means of access and should allow adequate space to assist cleansing operations.

The last-mentioned method is to be preferred, as milk has to pass through a minimum amount of pipe-line after the holding process has been completed.

The "Econom" pasteuriser is designed to heat and hold milk in one vessel. The product may, if desired, be given a preliminary cooling in the holder after treatment. The internal container is constructed of stainless steel or of copper, heavily tinned. Stainless steel is preferable, as, although tinned copper is durable, the possibility of destruction of the tinned surface owing to constant cleansing operations is obviated. The holder is surrounded with a jacket, the heating agent being low-pressure, low-temperature steam. The container may be insulated if required, resulting in a slight economy in steam. When the required temperature is attained, the steam is shut off and condensation takes place. During the time milk is held, a non-conducting vacuum is formed in the jacket. This is claimed to be more efficient than any form of insulation in preventing loss of heat during the holding process. As the container discharges, cold water is allowed to circulate through the jacket to effect a primary cooling of the milk. If water is used as a final cooling medium, a large surface cooler is recommended by the makers of the plant.

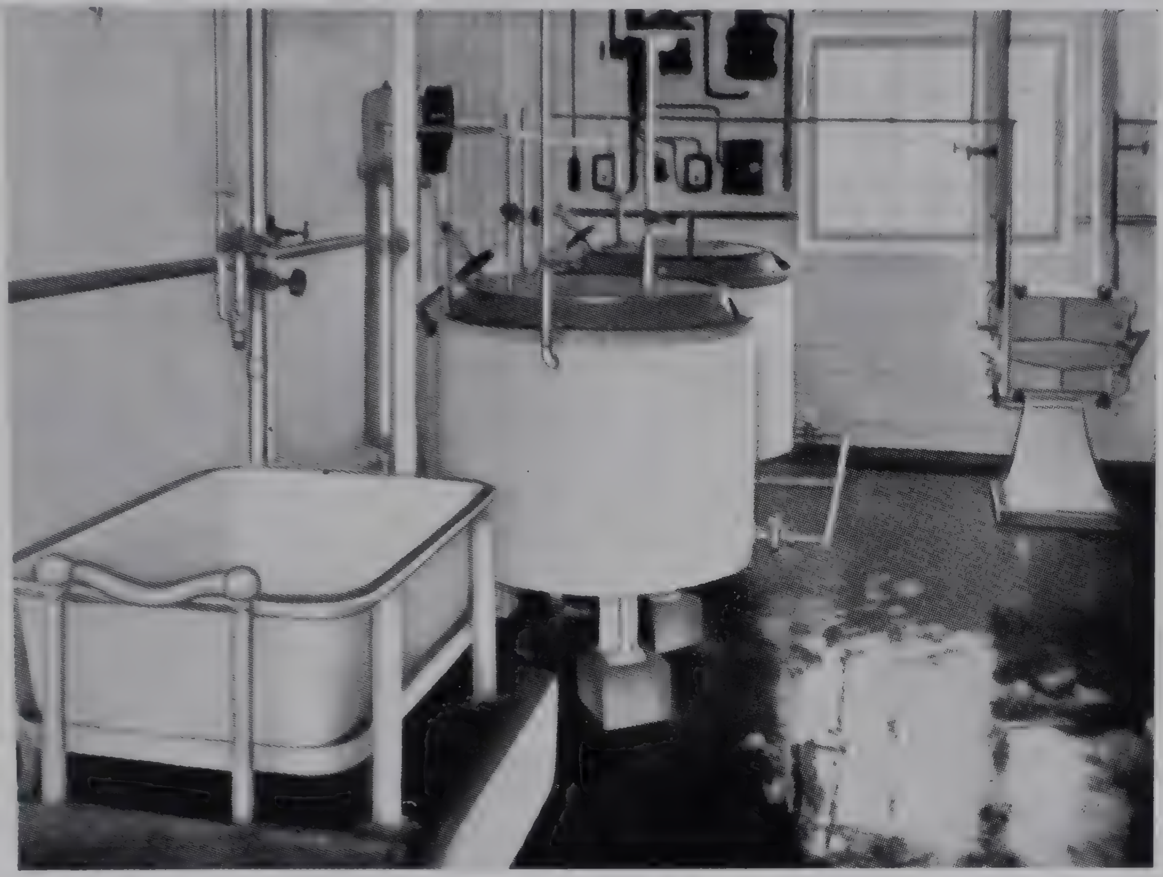
The holder may be heated by means of hot water in place of low-pressure steam. If this method is employed, the jacket surrounding the container is filled with water to the required level, steam being admitted to heat the water. Water is then withdrawn from the jacket and replaced by steam in order to form the vacuum essential to the holding process. A hot-water circulating boiler may be used if steam is not available.

Hand or mechanical agitation can also be fitted, the hand-driven type being standard. The hand agitator must be operated at regular intervals by the person in charge. In the power-driven types, the plunger moves slowly in a longitudinal direction. With the steam-turbine driven plunger, waste steam from the turbine can be used to pre-heat the milk. Agitators may be coupled when two or more holders are used.

The tanks are fitted with standard, non-recording thermometers, but *self-recording clockwork thermographs* should be provided. The self-recording *thermograph* is fitted in close proximity to the holder. In the usual type, a circular chart is rotated by clockwork, and one or two pens, as required, trace a continuous record of the time taken to attain the required temperature and the exact time during which milk is held at this temperature, together with any variations. The chart is marked in twelve one-hour divisions. *Thermostatic controls* can be supplied to operate in conjunction with the thermograph, provided electric power is available. These mechanically disconnect the heating agent when the required temperature has been attained, the entire process being automatic.

Filters used in conjunction with this type of plant are of two types :

(1) *Pipe-line Filter.* This consists of a circular steel box heavily tinned (see Fig. 94, p. 176). An air-tight lid is fitted, on the internal surface of which is a spring which presses on the perforated steel strainer plate. This plate covers a wire gauze disc, under which is placed the filter medium, the whole resting on a second perforated steel plate which in turn rests on a groove inside the box. The whole filter is quickly dismantled for cleansing and sterilisation. Milk enters at a point near the base, flows upwards, and is delivered through an upper outlet. A small quantity of milk remains after filtration. This should not be mixed with milk which has already passed through. For this reason a thorough cleansing of the filter after each operation is essential. The advantages of this type of filter are :



By courtesy of the Aluminium Plant and Vessel Co., Ltd.

FIG. 165. A.P.V. " Batch " Pasteurisers.

(*a*) It is entirely closed during operation, thus avoiding any atmospheric contamination.

(*b*) No wastage of milk by splashing occurs.

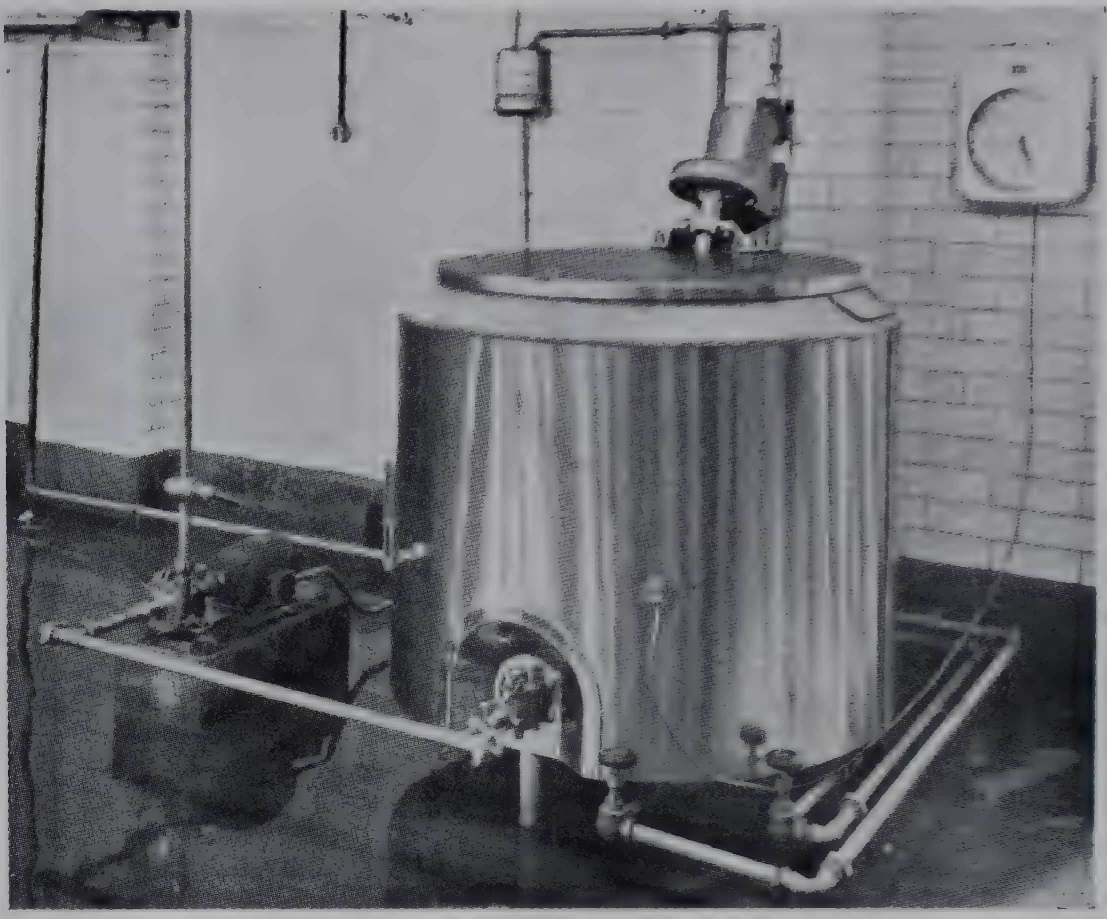
(*c*) Milk presses evenly on all parts of the filtering medium.

(*d*) Filtration takes place *against* gravity, so that all sediment drops to the base, thus eliminating the possibility of any dirt being washed through the filter.

(2) *Continuous Pipe-line Filter.* This filter consists of two pipe-line filters so coupled that one may be operated during the time taken to change the filtering medium in the other.

The *A.P.V. " Batch " Pasteuriser* is another efficient plant suitable for the small distributor. This type is provided with a closed circuit cooler in the form of a pedestal heat exchanger which possesses both water- and brine-cooled sections. This apparatus can be adapted for use with the vacuum and compressed-air system, avoiding any need of pumping. Fig. 165 illustrates a plant of this description, comprising two nickel "Batch" pasteurisers, tipping tank and pedestal heat exchanger-cooler.

The *C.P. Junior "Batch" Pasteuriser* is manufactured to a standard capacity of 100 gallons. The holder is constructed of stainless steel and is surrounded by a water jacket. The heating agent is a mixture of steam and water, and, during the heating period, the milk is agitated by means of a motor-driven paddle to ensure maintenance of a uniform temperature. The outer shell is also constructed of stainless steel, and covers the insulation, which takes the form of 1-inch cork slabs. A simple thermometer is provided as a standard fitting, but, if desired, a recording thermometer may also be fixed. The principle of operation is simple. The holder is filled by hand, after which the steam and water valves are opened to commence heating. The agitator is started up, and, when the milk has reached the required temperature, the heating valves and agitator are shut off for the entire holding period, heat being maintained by the cork insulation. After treatment, milk is pumped while hot through an "in the line" filter to the cooler. An open tubular cooler is provided which may be used for a single or double waterway, gravity feed being provided to the bottle filler.



By courtesy of the Creamery Package Co., Ltd.

FIG. 166. C.P. Type "B" Pasteurising Plant.

The final cooling agent may be brine or other refrigerating agent, and the plant is quickly and easily cleansed.

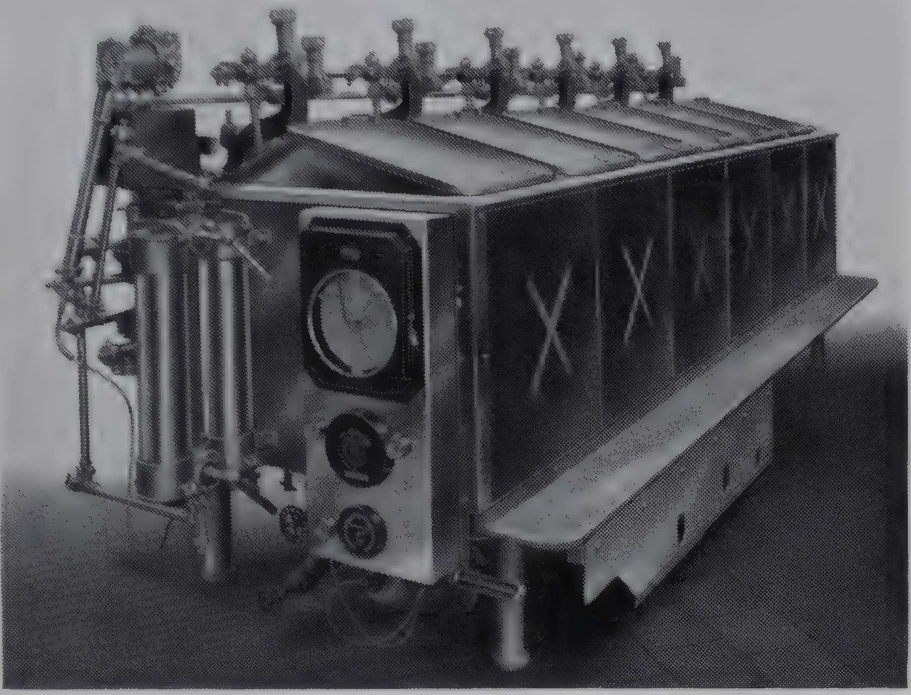
Plant for Large Dairies

While the small distributor may obtain plant at comparatively reasonable cost which will treat his milk in a satisfactory manner, the large distributor, by reason of the quantity of milk handled, must, of necessity, expend a large sum on his equipment. Details of some of the best-known types of large pasteurising plant are appended.

The C.P. Auto-Precision Pasteuriser

This plant has recently been designed to give exact precision in operation, complying with the requirements of the Ministry of Health. It is entirely self-contained with the exception of the separate cooler, and consists of heater, holder, which is divided into four compartments, and cooler.

The milk is pumped from the receiving tank through a three-stage heater and, after filtration, passes to one of the compartments in the holder. When the holding period has been completed, the milk is drawn by means of an exhaust pump to the compartment over the cooler. Temperature control is exceptionally complete, as full temperature recording is provided, while the temperatures of milk entering and leaving each compartment are also recorded. This plant is entirely automatic.



By courtesy of the Creamery Package Co., Ltd.

FIG. 167. C.P. Auto-Precision Pasteuriser.

The heating of heater and of the holding compartments is combined, the same heating medium serving both sections. The pre-heater tubes are of stainless steel and pass through the body of the holder. These can be rapidly dismantled for cleansing and sterilisation. The heating medium is steam-heated water, the heating of this water taking place away from the holding vessels. The volume of heating water circulated to the quantity of milk to be heated is in the proportion of twenty to one, heat interchange being remarkably complete.

The two main features of the plant are the temperature of the hot water used for heating and the automatic method of temperature control. The heating medium circulates continuously and is at no time higher than the pasteurising temperature. The temperature-regulating system is operated by means of compressed air. Any increase or decrease in the temperature of the heating medium is instantly balanced by the closing or opening of the steam regulator valve, and there is no possible chance of either insufficient or excessive heating. The holder compartments are constructed of stainless steel with all corners rounded off, a sump and a draw-off plug being provided in each compartment. During the holding process they are sealed from the atmosphere. They are also provided with agitators.

Milk after treatment is drawn off from the bottom of each compartment, the inlet pipes being carried to a similar position to ensure absence of foaming during filling operations Inlet and outlet valves are of the positive type and, when closed, " break " the flow pipe-line, thus preventing untreated milk passing to the holders. By-passes are provided for any leakages from valves.

The cooler is of the tubular surface type, the size being arranged to suit the capacity of the holder. Cooling is primarily carried out by water followed by treatment with chilled water, brine, or by direct expansion refrigeration. A large surface area is provided to ensure rapid cooling, while a flow distributor is fixed to secure a thin, even film of milk over the entire cooling surface.

The plant, being entirely automatic, is simple to operate, one gear control lever starting the whole apparatus in motion. It occupies a remarkably small space for its capacity.

The A.P.V. Pasteuriser

This is one of the most popular types of plant both in this country and on the Continent. It has been designed with five main objects in view, as follows :

(1) To provide a plant in which milk, during all heating and cooling operations, is not in contact with the air, thus preventing any risk of air-born econtamination.

(2) To ensure that every surface brought into contact with milk can be readily cleansed, and that the whole plant allows of easy sterilisation before and after running.

(3) To provide a method of heating in which it is not essential to bring milk into contact with any steam-heated surface.

(4) To enable the entire processing to be carried out with economy and without creation of foam.

(5) To provide a plant in which efficiency of heating and cooling can be reliably calculated, and in which such efficiency remains unaffected by water, brine impurities, or scale.

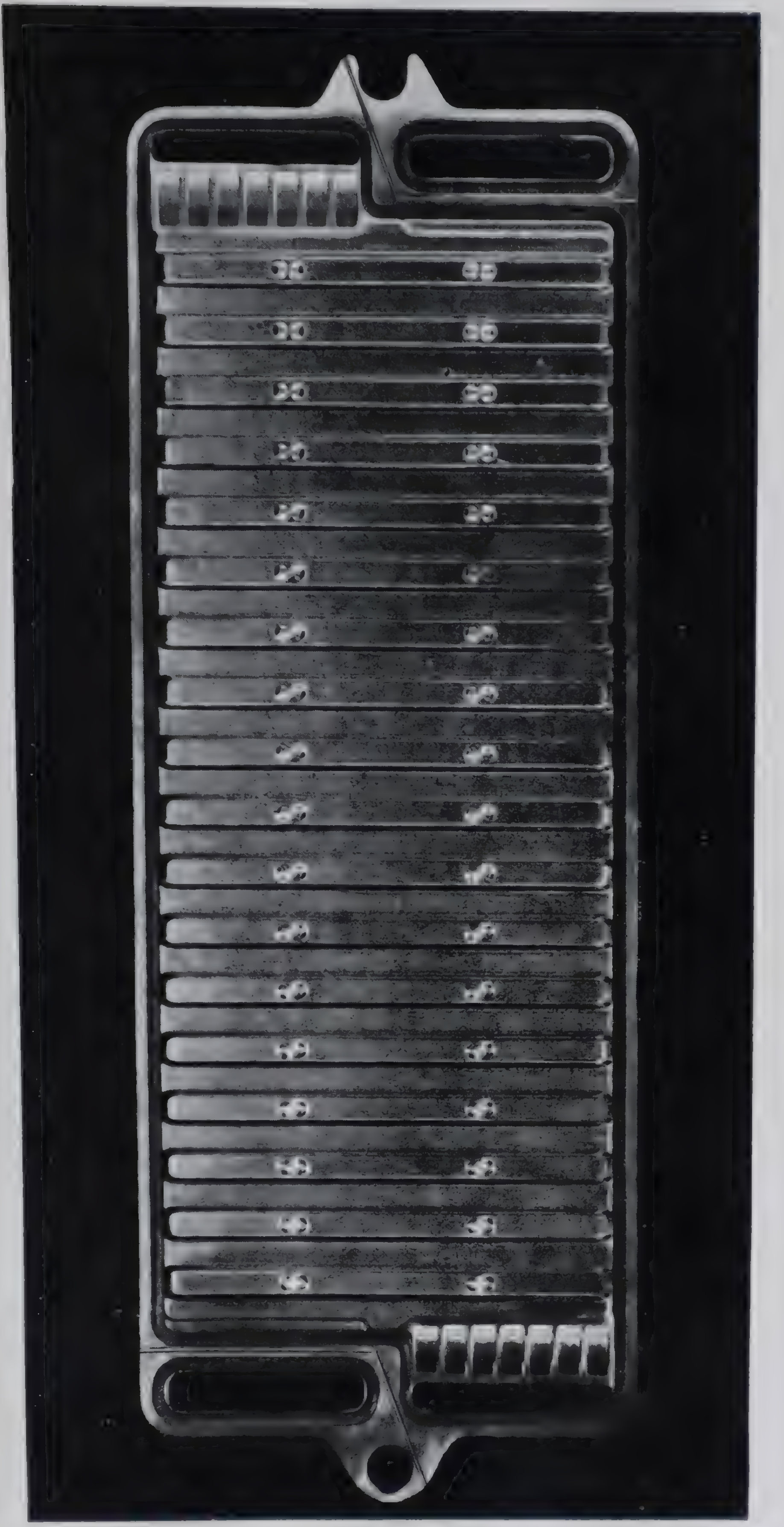
The principal features of this plant are :

(1) *Plate Heat Exchanger.* This is built up of a number of heavily tinned rectangular cast gunmetal or stainless steel plates grooved on both sides. Similar plates are superimposed over these and are firmly secured, converting the grooves into shallow channels, the whole being tightly bolted together.

The milk to be heated (or cooled) flows across one side of the plate and the heating (or cooling) water flows across the other side in the opposite direction. By means of the metal plates, these liquids exchange heat, and, owing to the long shallow nature of the grooves, such interchange is extremely rapid. The machine is constructed in sections, and the plates are fixed about ¼ inch apart. This machine, which occupies a small floor area, will carry out the operations of heating and cooling up to 6,000 gallons of milk per hour.

This apparatus embodies a new principle of heat interchange, a ribbon flow being followed by a pulsating effect upon the fluid passing through, this effect being attained by means of certain details incorporated in the design. This results in quick transference of heat and gives economy of working. The advantages claimed for the plate heat-exchanger are :

(*a*) Milk is not brought into contact with any steam-heated surfaces, since heating, when not carried out by the treated milk, is attained by water only a few degrees higher in temperature than the milk itself.



By courtesy of the Aluminium Plant and Vessel Co., Ltd.

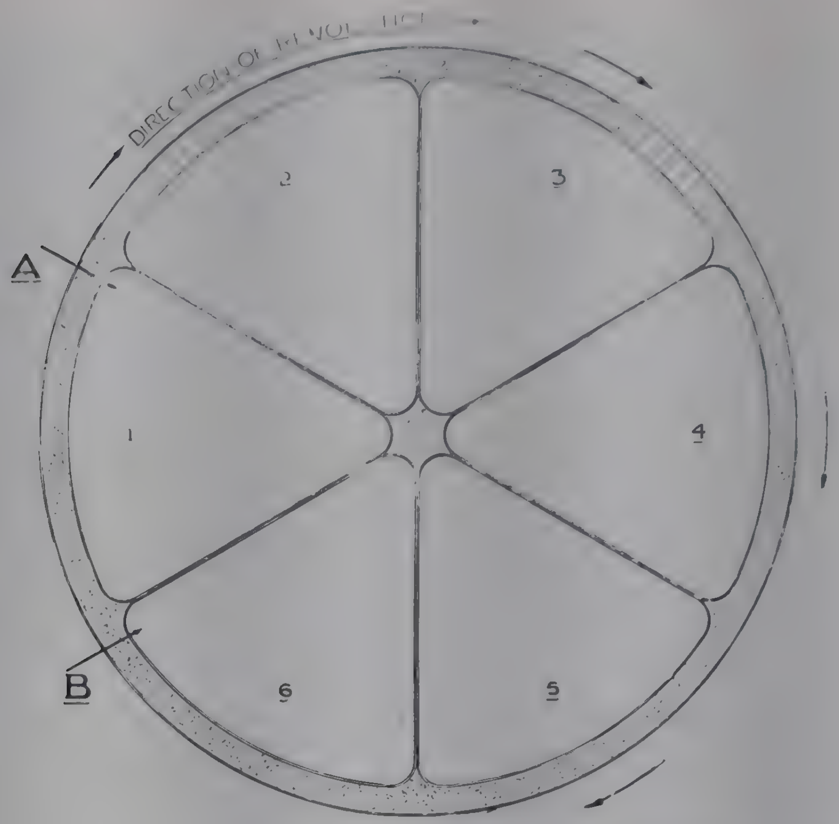
FIG. 168. A.P.V. Heat Exchanger Plate.

(*b*) Milk is never in contact with air, thus avoiding contamination and oxidation.

(*c*) There is a complete absence of foaming.

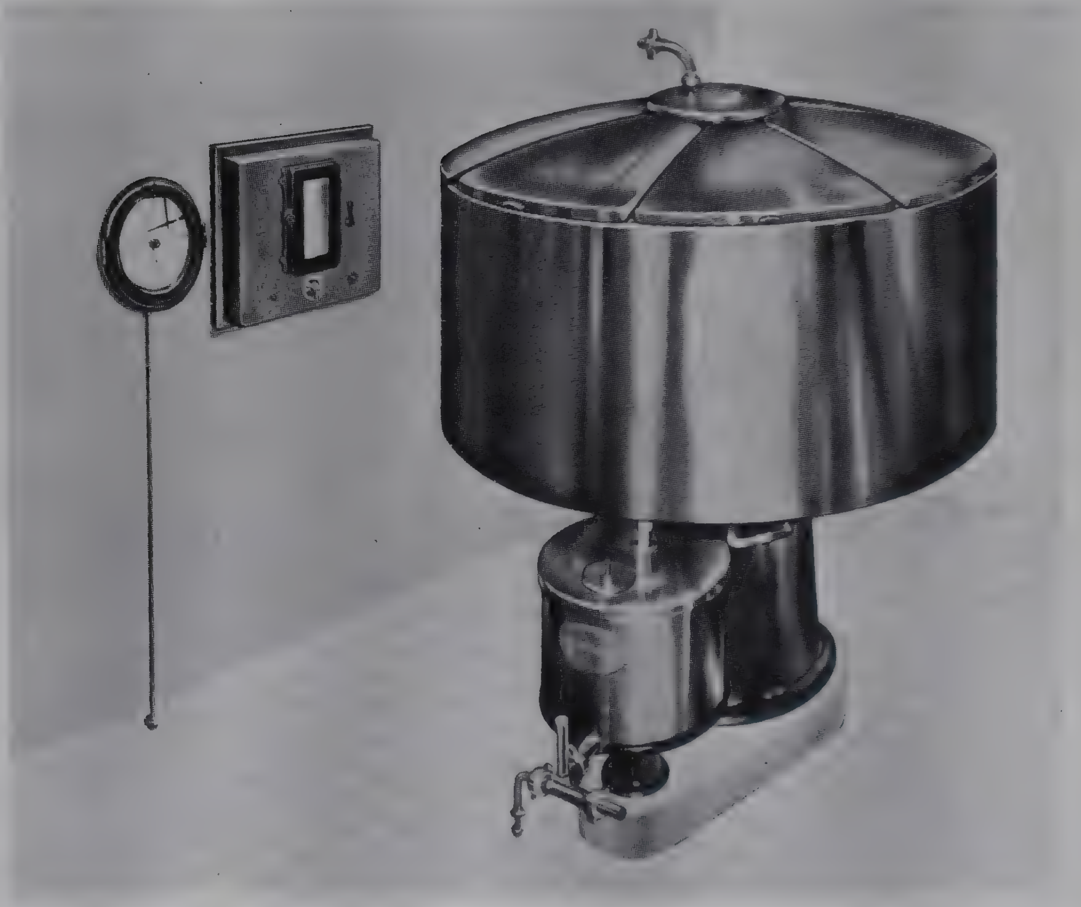
(*d*) The machine is easily examined, cleansed with an ordinary brush, and sterilised by steam.

(*e*) There are no losses from evaporation such as take place when hot



By courtesy of the Aluminium Plant and Vessel Co., Ltd.

FIG. 169. A.P.V. "Tarbet" Holder (Plan).



By courtesy of the Aluminium Plant and Vessel Co., Ltd.

FIG. 170. A.P.V. "Tarbet" Holder.

milk is passed over an open cooler. (This loss often amounts to 1 per cent. of the total milk treated.)

(*f*) A saving of 50 per cent. in the steam normally required for use is secured.

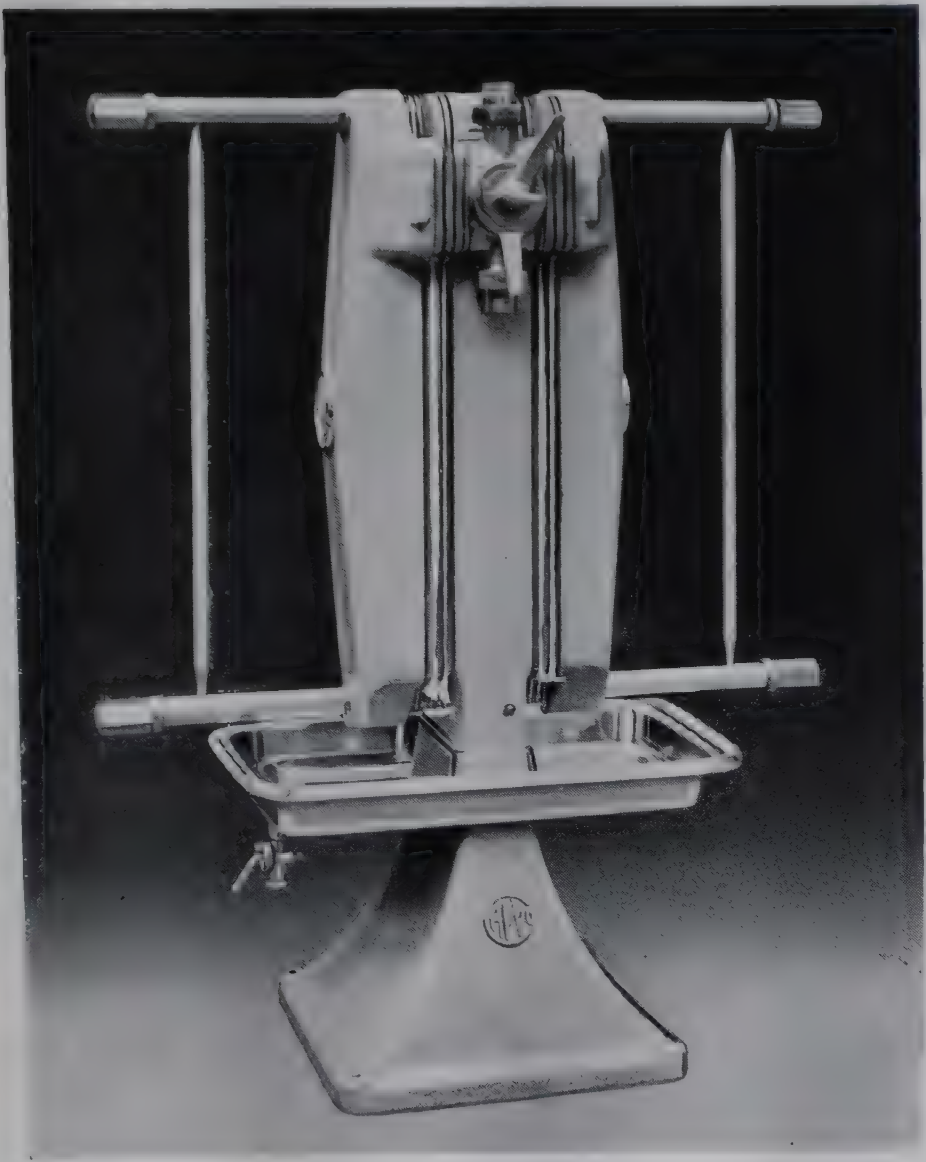
(*g*) Great saving in floor space is effected.

(2) *Vacuum and Compressed-air System of Operation.* This system has been

made possible by the development of the closed-circuit pre-heater and cooler. All the operations necessary may be effected without pumping, by means of vacuum suction and compressed-air propulsion. The process is independent of gravity or external conditions, and possesses the following advantages :

(*a*) It is operated on one floor without the use of pumps and independent of valves, milk being moved throughout the process by means of compressed air and vacuum. From heating to bottling, milk flows naturally. As the pumping of cold milk affects the cream-line, this is important.

(*b*) During the entire process, milk remains in a closed circuit with no exposure to the atmosphere, oxidising action and contamination being therefore eliminated.



By courtesy of the Aluminium Plant and Vessel Co., Ltd.

FIG. 171. A.P.V. Continuous Milk Filter (Closed).

(*c*) The entire operation is performed automatically, labour charges being thus reduced.

(*d*) Milk passes through no cocks or valves which require setting either automatically or by hand.

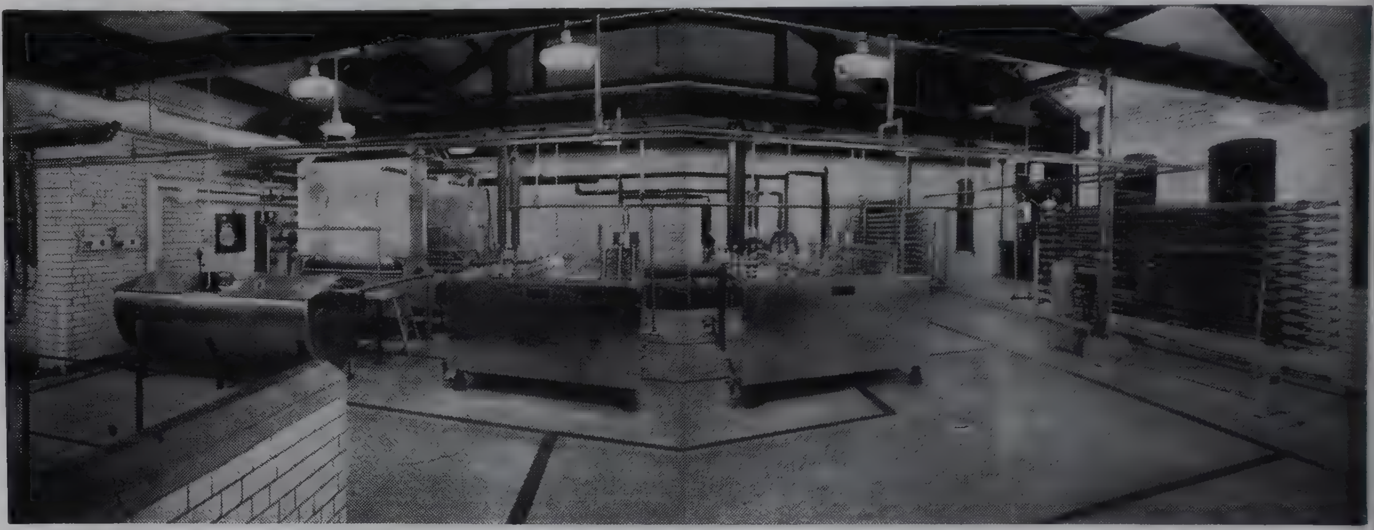
(*e*) Nothing moves except milk.

(*f*) The process is always *positive*.

When one holder has been filled, the vacuum is transferred to the remaining tanks alternately, these being filled in rotation. Each tank is allowed to remain full for the predetermined period of thirty minutes, and, when this time has elapsed, each holder is discharged by means of compressed air which has been previously washed and filtered and which drives the milk from the tanks. The capacity of this type of plant varies from 400 to 6,000 gallons of milk per hour. The operation of vacuum and compressed-air supplies is automatically controlled and no milk can enter or leave the holder until air pressure has been applied. When the tanks are being filled, the hot milk is under reduced pressure to facilitate the escape of any " off odours." The flow of milk is easily controlled by opening or closing of the vacuum or compressed-air valves, while the processing in the holders may be observed through special sight glasses provided.

(3) *Tarbet Positive Holder.* This type of holder is installed by many distributors in preference to the vacuum and compressed-air system.

The apparatus is divided into six separate compartments, each making one complete rotation in forty-five minutes. The operation of the holder is illustrated in Fig. 169. At point A, milk from the heater is flowing continuously into the compartment below. Each compartment remains stationary for seven and a half minutes, during which time it fills with liquid. After leaving point A, the compartment moves slowly round in a clockwise direction to point B. It remains stationary at this point for seven and a half minutes, during which time it discharges milk into a receiving tank below. From this position milk is either pumped or flows by gravity to the cooler. The time taken to move from point A to point B is exactly thirty minutes, as required by the Order of 1936. During the process one tank is filling, four are holding milk and one is discharging. The following advantages are claimed for the process :



By courtesy of Cherry-Burrell, Ltd.

FIG. 172. Complete Cherry-Burrell Pasteurising Plant, showing Heater, Holders and Cooler.

(*a*) The whole volume of milk is held within the limits of temperature required.

(*b*) The entire quantity is retained inside the apparatus and none can remain in pipe-lines outside the holder compartments.

(*c*) There are no supply or discharge pipes common to the various tanks. It is therefore impossible for leaking valves to allow partially-treated milk to pass out to the cooler, or for treated or untreated milk to mix.

(*d*) The operations follow in correct order without any manual control.

(*e*) Milk is unable to enter any compartment until the outlet is closed.

(*f*) There is a minimum of valves and pipes.

(*g*) There are no " stuffing boxes " in contact with milk.

(*h*) The operation of the holder does not create foam or agitate the milk excessively.

The holder is hydraulically driven from the ordinary water supply.

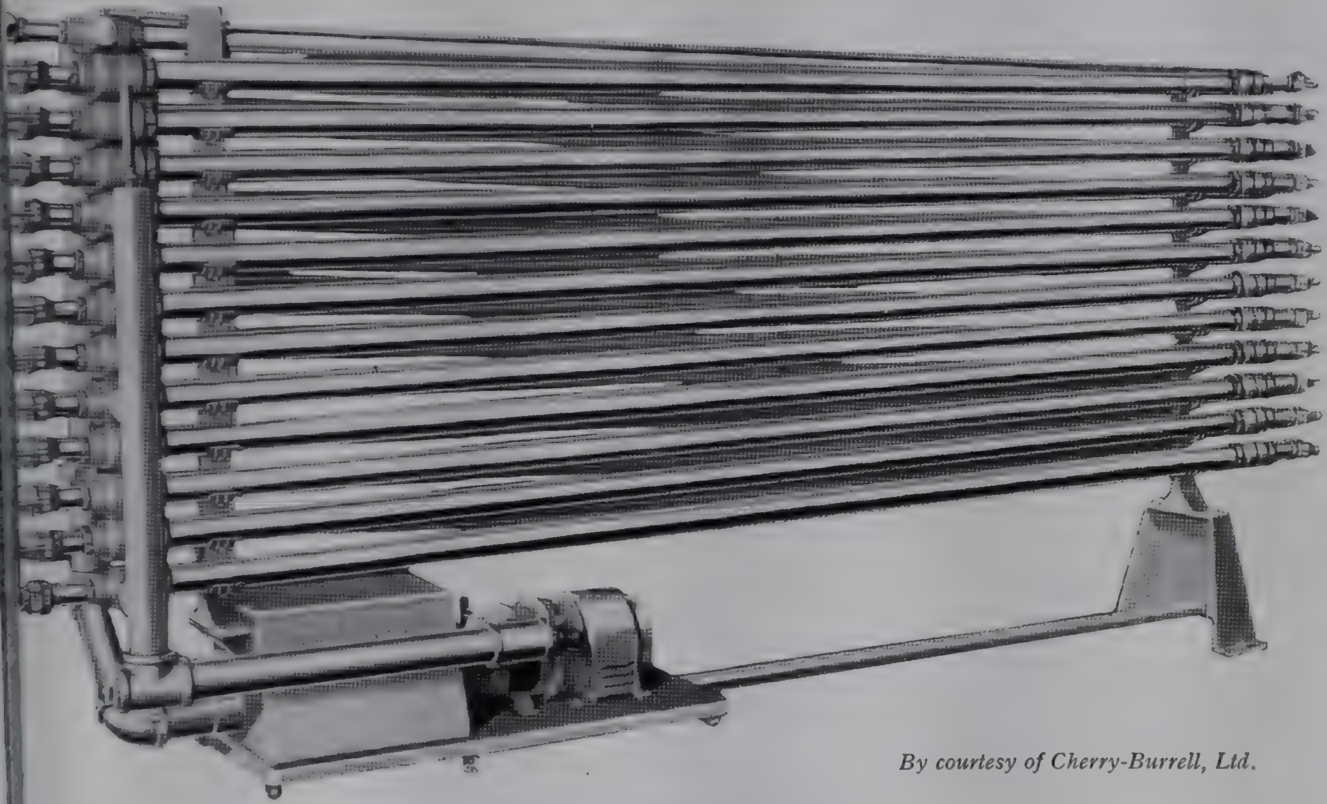
(4) *Continuous Filter.* The milk filter is rapidly taking the place of the clarifier. Probably the greatest advantage possessed by this filter is the fact that it is possible to change the filtering medium without interruption of processing and without any need for " breaking " pipe-line joints. In the past, the greatest drawback to filters has been choking of the medium, rendering it essential for the process to be interrupted whilst new filtering material was fitted. To do this it was generally necessary to " break " one or more pipe-line con-

nections with a consequent loss of milk. To avoid this interruption, two filters are usually fitted, with a consequent complication of pipes and occupation of valuable space. The A.P.V. filter is really two distinct filters combined in one body, each working independently of the other, so that one may be opened while the other is in operation. They are becoming increasingly popular, as they allow adequate filtration of milk without additional machinery and lend themselves to the "closed-circuit" method of treatment now so much in vogue.

The various parts of the A.P.V. plant are easily accessible for cleansing purposes, being quickly dismantled and reassembled.

Cherry-Burrell Pasteurisers

This system does not differ materially from the standard types of pasteurisation plant, but, by the provision of efficient temperature controls and automatic stopping and starting devices, labour can be almost entirely eliminated. The plant is divided into three distinct portions, as follows :



By courtesy of Cherry-Burrell, Ltd.

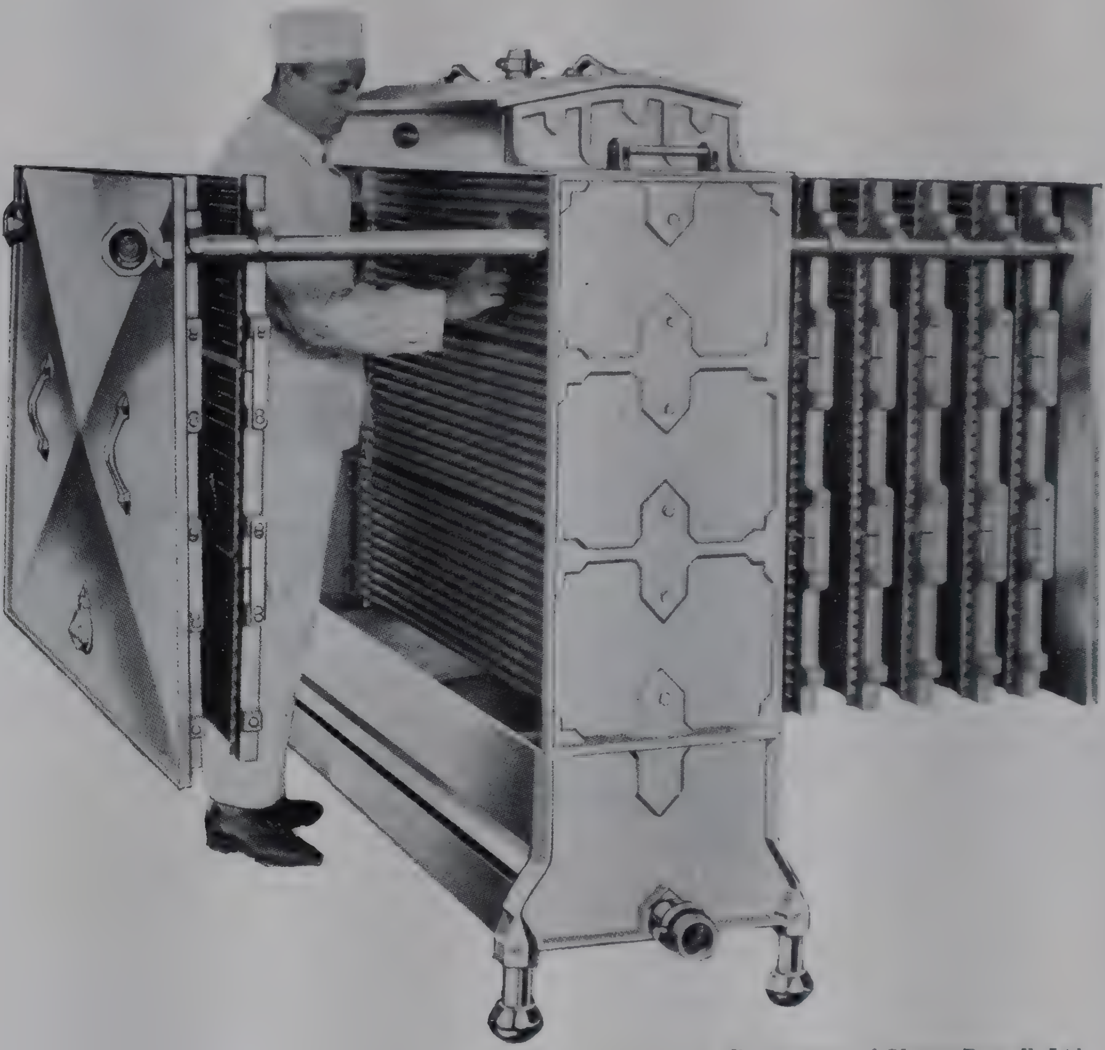
FIG. 173. Uniflex Heater.

(1) *The Heater.* The "Uniflex" Internal Tube Section heater consists of a bank of double tubes. Hot water which is used for heating circulates through the annular space between the tubes, and milk after filtration passes through the inner tube. Two types of heater may be obtained. For plants with a capacity of 300 gallons of milk per hour, the heater has single or double heat control. If over 300 gallons of milk require to be treated per hour, double-response heat control is fitted. The temperature of the heating water is lower than in many types of plant, this being made possible by the design of the heater and by the circulation of a quantity of water in high ratio to the quantity of milk treated. Perfect temperature control is obtained, the makers claiming that temperatures can be controlled to within one-tenth of a degree Fahrenheit during processing.

(2) *The Holder.* In this system, no re-contamination of the milk due to faulty valves is possible. Milk is fed into the holder from below to avoid the formation of foam, and after treatment, is drawn off by entirely separate pipes. It is impossible for any untreated milk to come into contact with milk which has been processed. The holder is divided into compartments which are filled by means of a divided bowl, over which a revolving cover directs the milk to each compartment in turn. The holder compartments are constructed in two

groups with the controlling mechanism in the centre. The inner tanks are manufactured from chrome-nickel steel, and are well insulated by means of an air jacket which overcomes any difficulty likely to arise on account of temperature drop during the holding period. The air between the inner and outer tanks is heated by means of a steam coil to a temperature several degrees higher than is required for the process. This minimises heat-loss which occurs when water is used. The temperature of the milk is not affected during the holding period, although the air temperature in the jacket may be higher than 145° F. A paddle agitator is fitted to each compartment, which moves at the rate of six revolutions per minute, thus ensuring complete uniformity of temperature. Tightly fitting, heavily insulated covers are provided to prevent air contamination and loss by evaporation.

The milk is discharged from the holders by means of siphonic action. The siphonage is started by a rotary pump, and, when discharge has begun, the milk continues to leave the compartments by gravitation, the pump acting as a regulator to the flow. When the gravity system of discharge is in operation it is difficult to maintain an even flow of milk over the cooler, this being due to the head of milk at the commencement of discharge which is liable to overtax the apparatus. This allows a considerable quantity of milk to be improperly cooled. Similarly, when the tank is almost empty, the head of milk is decreased, only a small quantity passing over the cooler, the result being that such liquid as is passing is overcooled, often being frozen on the lower section of the cooler. By reason of the regulated siphon provided, an unvarying flow of milk to the cooler is maintained which ensures maximum cooling at all times. All the working parts and controls are encased in the central cabinet. These controls are entirely automatic and efficient temperature recorders and controllers are provided at requisite points.



By courtesy of Cherry-Burrell, Ltd

FIG. 174. Cabinet Cooler (Open).

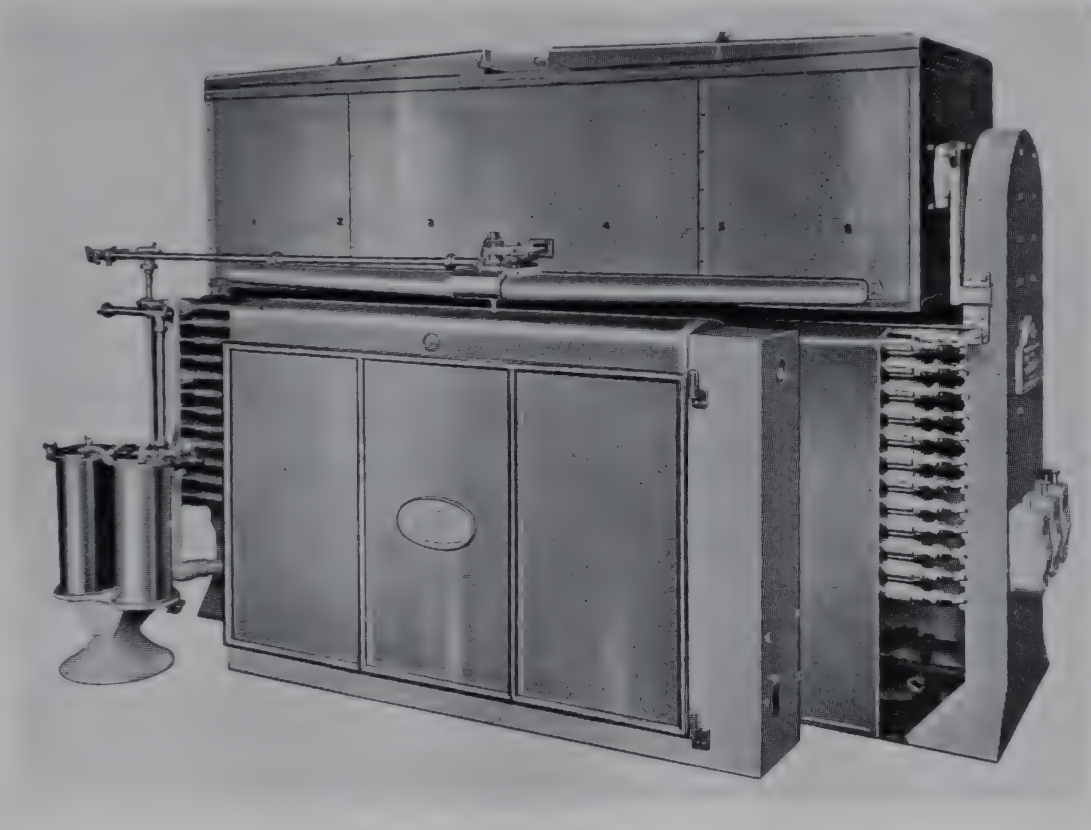
(3) *The Cooler.* A cabinet cooler is available in all sizes, to treat from

200 gallons of milk per hour upwards. It is claimed that, owing to its design, there is a considerable saving in refrigeration costs and a material improvement in the quality of milk treated. This cooler is capable of reducing the temperature of milk from 145° F. to 40° F. in three seconds, and, owing to the height of the cooling surface (4 feet), a minimum of agitation occurs during the process. The cooler supplies a large cooling surface and the tubes are of small diameter. Owing to the large surface area, brine or chilled water at a much higher temperature may be used, with consequent saving in refrigeration costs.

The GEM Unified Treatment

This plant is designed to overcome the large amount of space, complicated pipe-lines and separate units met with in so many forms of apparatus. This has the effect, not only of reducing the capital cost of plant and buildings, but also of effecting a considerable reduction in labour costs and maintenance expenses.

This machine, designed by the Graham-Enock Manufacturing Company, is a complete milk treatment plant, compact yet simple, and complying in every respect with the requirements of the Ministry of Health. No pumps or vacuum pipes are required, the flow of milk being entirely dependent upon gravity. The milk is at no time in contact with air during treatment, while metal surfaces in contact with the fluid are constructed of stainless steel, thus rendering cleansing a comparatively simple operation.



By courtesy of the Graham-Enock Mfg. Co., Ltd.

FIG. 175. "GEM" Milk Treatment Machine.

By reason of its small size (a complete 400 gallons per hour unit occupies a floor space approximately 11 × 4 feet) the apparatus can be installed in a very small space. Units are constructed in various sizes to treat any quantity of milk from 75 to 2,000 gallons per hour. Milk is first pre-heated by regeneration, the heated milk from the holder exchanging its heat with incoming cold milk. This partially-heated milk receives a further heating to a temperature of 145° F. by a tubular pre-heater, milk passing through the inner tube being heated by hot water in the annular space surrounding this tube. The milk tubes are constructed of stainless steel and are easily accessible for cleansing purposes. Automatic temperature control is provided which facilitates accurate working. After final heating, milk passes to the holding portion of the apparatus, into a set of insulated vessels where it is held for the necessary period. The holder is so constructed that the entire volume of milk is drained from the vessels into the cooling section, there being no pipes between holder, cooler, and cold milk balance. Separate outlet valves deliver the milk directly over the cooler, any leakage from valves being led away to waste. The holding vessels are mounted over the cooling section on top of the machine and swing down for cleansing purposes. There are no dead-ends or by-passes. On leaving the holder, milk is cooled to a temperature of 40° F. in three stages. The primary cooling takes place by heat-exchange with incoming cold milk ; a secondary cooling is given by mains water to within two or three degrees of the temperature of such water, while final cooling is effected by means of chilled water. "Freezing-on" with consequent injury to cream-line is avoided. Arrangements are incorporated whereby the heater can be used to raise the temperature of milk to 145° F. without regeneration during the first half-hour after the plant has commenced to operate, when no hot milk is passing through the regenerator. An additional water supply is passed through the mains water-cooling section during the last half-hour the plant is in operation, when there is no incoming cold milk to pre-cool the hot milk.

All controls are centralised, and the instrument panel shows :

(1) Temperature of hot milk.
(2) Temperature of cold milk.
(3) Temperature of chilled water.

Recording instruments can be fitted if desired, this being advisable. Special sight windows are provided, by means of which processing can be noted.

This plant solves the problem of the distributor who has little space at his disposal and who, for economic reasons, cannot alter or rearrange his premises. It should appeal to such distributors as a solution to their many difficulties.

In-Bottle Pasteurisation

The idea of pasteurising milk in bottles is not new, but although it has been realised for some long time that milk could be treated in this manner, the method has only become a sound, hygienic proposition within the last few years. In 1908, Heineman, in America, noting that beer was pasteurised in bottles, experimented with milk on similar lines. Several methods were the subject of experiment but none appeared to be successful. Difficulties arose on account of the type of bottle or closure employed, and owing to the imprisonment of odours and flavours due to heating milk *from cold* in tightly-sealed bottles. It was not until after the last war that steps were taken in this country by Arthur G. Enock (1928) to design a plant which could usefully be employed to treat milk in bottles and one which overcame some of the main inherent objections, and it is only during the last fifteen years that plants have been placed on the market as a commercial proposition.

The chief difference between this method and the low- or high-temperature holding processes is that milk after preheating is filled directly into hot sterile bottles which are immediately capped. These pass to the holding chamber, where they are held at the correct temperature for the prescribed period after which cooling takes place.

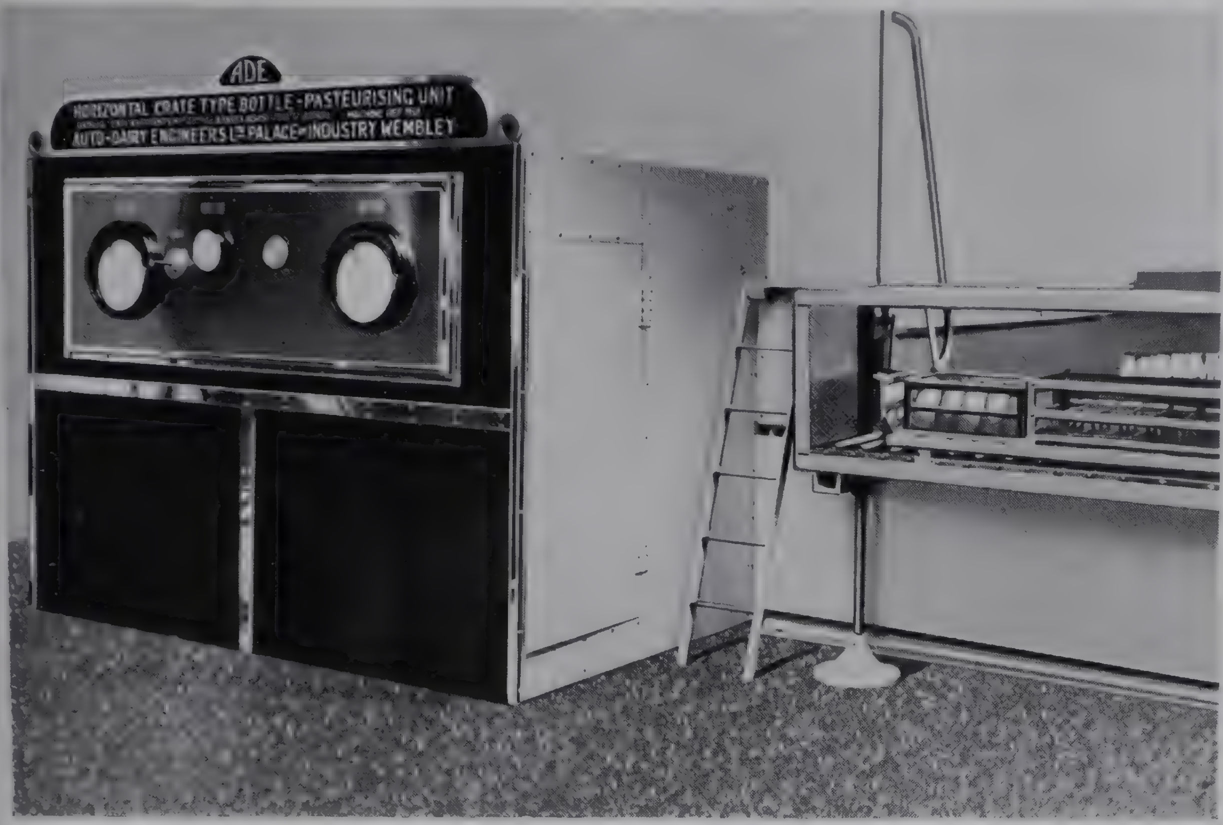
The advantages to be gained from this method of treatment are :

(1) Positive destruction of all pathogenic organisms together with the greater portion of the non-pathogenic bacterial content with the result that milk treated in this manner possesses lengthy keeping qualities.

(2) Re-contamination of the milk after treatment avoided.

(3) As the bottles and their closures are heat-treated along with the milk, risks arising from unsterile bottles and caps and from human contamination are prevented.

(4) No waste of time in processing due to filling or discharging holder compartments, no risk of unpasteurised foam and no leakages of raw milk into treated milk.


ADE
HORIZONTAL CRATE TYPE BOTTLE-PASTEURISING UNIT
AUTO-DAIRY ENGINEERS LTD PALACE OF INDUSTRY WEMBLEY

By courtesy of Auto-Dairy Engineers, Ltd.

FIG. 176. "A.D.E." In-Bottle Pasteurising Plant.
(Horizontal type showing control panel and delivery of bottles into holding chamber.)

(5) No milk can be pasteurised twice and risk of thermophilic infection is avoided.

(6) No differences in temperature which may occur in bulked milk or risk of heat losses or losses due to evaporation.

(7) No danger of milk receiving metallic contamination, and flavours or odours are evacuated during the heating process.

(8) The milk possesses exceptionally good keeping qualities.

(9) The process is extremely economical in the use of labour and in cost of water, steam, and detergents required, while no subsidiary apparatus is necessary.

(10) Automatic action places the results of processing beyond the operator's carelessness.

(11) Good cream-line is evidenced in the finished product.

Probably the most serious objection which can be raised to this method of treatment is the cost of the apparatus, which is primarily rather higher than the usual type of processing plant, but against this can be offset the many economic advantages obtained. From the public health view-point the great advantage and one which outweighs all others, is the freedom of milk after treatment from the possibility of any re-contamination either from the atmosphere, flies, the apparatus or by human agency. One must always remember that many types of disease-producing organisms are not present in milk as it leaves the cow, but obtain entrance between production and bottling. From a commercial viewpoint, souring is eliminated and the consumer satisfied.

The milk treatment routine is briefly as follows : The raw milk, after it leaves the tipping tank passes to storage tanks, from which, by means of quantity control pumps, it is delivered through filters and over stainless steel milk heaters of the ventilated type, heated by internal water circulation. The quantity of milk passing over and the temperature are automatically controlled so that the milk temperature is raised to the pasteurising point required. This operation assists contained gases and odours to escape, and this action is later assisted by de-aeration of milk when filled by vacuum action, which assists in the evacuation of those odours which are only liberated at higher temperatures. This aeration and de-oxygenation prevent the destruction of ascorbic acid and preserve vitamin C. The milk is heated to 147° F., after which it gravitates through an exceedingly short jacketed pipe-line to the receiver of the vacuum-operated bottle filling machine. This receiver is hot-water jacketed and the milk is filled into hot sterile bottles as delivered from the washing machine These washing machines have already received mention on pages 227 and 229. The bottles are capped, held for the requisite thirty minutes and finally cooled.

One of the first plants designed for this method of treatment which was used commercially in this country was the *vertical* type, and this apparatus possessed a holding chamber provided with " air-bells " or " domes," in which bottles were suspended. The " air-bells " travelled upwards and downwards through an air-heated holding chamber, this heating agent maintaining the closures in dry condition. The milk was held at a temperature of 147° F. for thirty minutes, and at the expiration of this period, the bottles passed through a chamber which had circulations of warm, mains and refrigerated waters, being gradually cooled to 40° F. While the " domes " were submerged the manufacturers claimed that the closures could not be affected by the cooling agent as it was not possible for water to rise higher than some $\frac{3}{4}$ inch below the bottle lip on account of air inside the " dome."

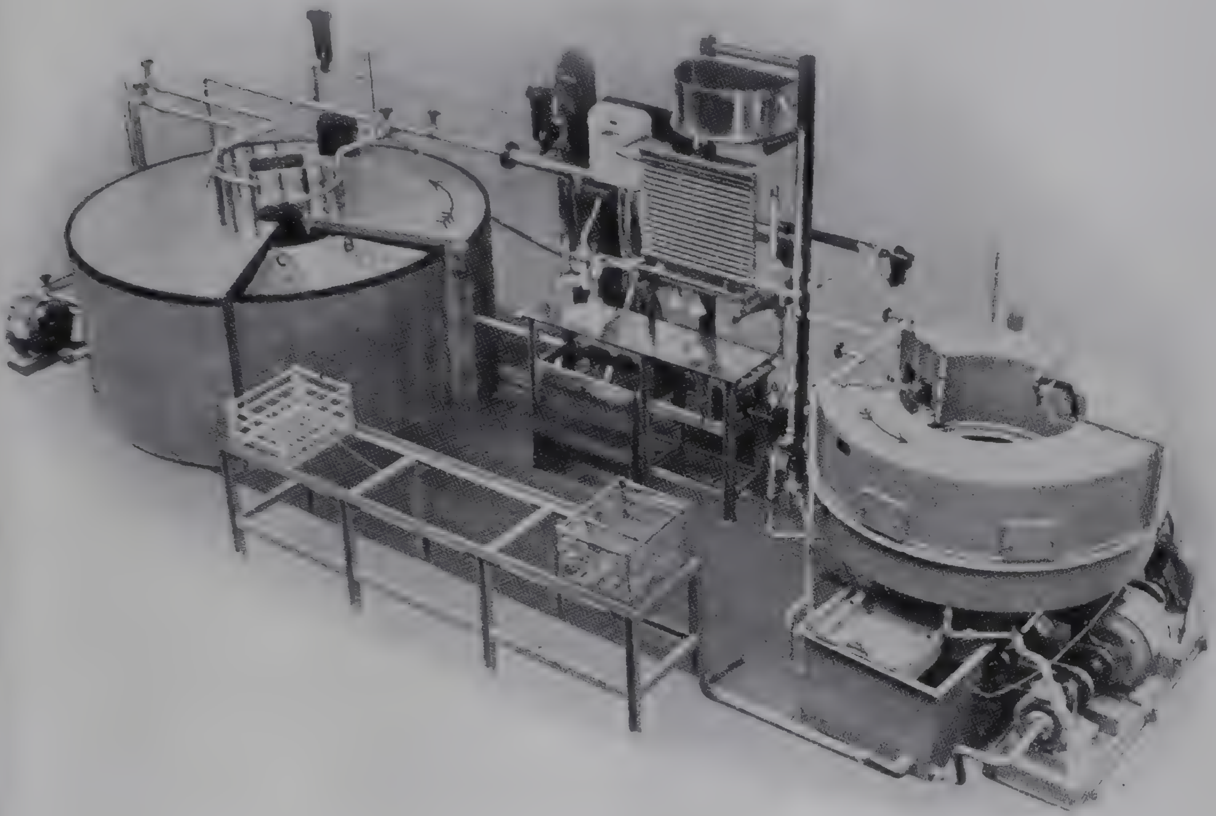
This type of plant possessed the following disadvantages :

(1) There was some slight cooling of milk between heating and holding. This was remedied in later models by jacketing the balance tank of the bottle-filling machine and enclosing the bottle conveyors by heated shrouds.

(2) Delay which occurred during the time the separate bottles had to be fitted into the " domes " of the holder.

(3) No method which would give an accurate check of the holding temperature of bottles during processing was possible, excepting the thermograph of the holding chamber and an occasional test made by placing a bottle thermograph into a traversing bottle.

In order to overcome these disadvantages, the *horizontal* type was designed, and the principle on which it operates is entirely at variance with customary methods. This apparatus deals with large quantities of milk on straight-line working. The bottles when filled and capped are placed in clean warm crates and the crated bottles then traverse the holding chamber and cooling tanks which follow. This holding chamber is constructed in the form of a long tunnel, which each crate of bottles traverses in exactly thirty minutes at a temperature of 147° F., hot air being employed as the heating agent and no temperature drop occurs. Efficient temperature control is provided and adequate openings into the hot-air tunnel are designed to facilitate removal of sample bottles for checking the milk temperature. A bottle thermograph is regularly traversed in the bottles. In practice the inspector's maximum and minimum testing thermometers may be inserted into a test bottle as it enters the holding chamber, the temperature drop being normally one-half to one degree during its journey. The crates and their contents pass through cooling tanks, the bottles being submerged to milk level, leaving a sufficient portion of the bottle above water level to prevent the entrance of any cooling agent. The water flows in the opposite direction to that of the bottles, ensuring complete interchange of heat, four stages of cooling being provided.



By courtesy of Auto-Dairy Engineers, Ltd.

FIG. 177. "A.D.E." Rotary In-bottle Pasteuriser.

For the small distributor a *rotary* apparatus has been designed working on the same principle as the horizontal type mentioned above.

In another type of apparatus, hot milk is filled into hot bottles, which are crown corked and are then passed to the holding tank. This contains water maintained at a temperature of 146°–147° F., situated in the base of the apparatus. Time and temperature are maintained during the passage of the bottles through this section, and when treatment is completed, they pass to the cooling section. Here they are cooled at varying temperatures down to 60° F. The water in the cooling tanks is the overflow from the cooling sprays and bottles are carried against the flow of cooling agent during their progress through the tanks. A further cooling down to 35° F. is given by means of water sprays, the final stage being refrigerated water. In all, eleven stages of cooling are given. Crown corks form a perfect seal, preventing the escape of milk and the entrance of cooling water into the bottles.

Damage to bottles is obviated in all processes by their gradual passage through water of varying degrees of temperature, the whole cooling process occupying half an hour. Some objections have been voiced that the milk is not *immediately* cooled as required by the Milk (Special Designations) Order. This Order does not require that the milk shall be *rapidly* cooled. The immediate and even rapid cooling of milk is certainly desirable when it is exposed to danger of re-contamination, but when the liquid is enclosed in a sealed, glass container, immediate cooling does not assume the same importance. Ayers and Johnson, in the United States of America, have shown that there is no great increase in the numbers of organisms present in milk which has taken five hours to cool when compared with milk cooled in much shorter time. This is stated to be due to the influence of the pasteurising temperature upon bacteria. Those surviving the process are temporarily weakened and require some time to recover their natural vitality. Rapid cooling, it should be remembered, does not increase the destructive effect of pasteurisation.

The advent of the High-temperature Short-time process has caused preliminary trials to be made with a view to applying this process to the treatment of milk in bottles. Details of the present position are set out on pages 323 and 324.

Cleansing of Plant

The cleansing of dairy equipment must always be regarded as a major operation, as it may be quickly ruined and the product rendered unsatisfactory if improper cleansing methods are adopted. The temperature differences between the heating media and milk, and failure to speedily cool equipment and wash it thoroughly after use not only cause milk solids to become burnt on the internal surfaces of appliances, but the bacterial content of milk subsequently treated may possess a bacterial content so excessive as to render processing a waste of time, energy and expense. Another important factor must also be considered. Mineral salts are bound together by milk proteins and fat, and this milk fat must be emulsified and the proteins softened and removed so that the whole may be carried away by the detegent solution.

It is important that all parts of pasteurising plant, whatever type is used, and its subsidiary apparatus, should be efficiently cleansed and sterilised at the end of each " run," while it is also imperative that strict routine should be adhered to and the work performed under proper supervision. Lack of care in cleansing operations will result in an unsatisfactory product on the following day ; indeed, many of the disappointing results obtained from well-designed plants are actually the result of such carelessness.

Washing operations are necessary to remove all traces of milk remaining after processing in order to leave a clean surface suitable for subsequent sterilisation. Washing alone is not sufficient, sterilisation being necessary and extremely important. For correct sterilisation, some form of heat is essential, either steam, hot water or hot air being employed. The two main factors deciding whether sterilisation is satisfactory are the temperature to which surfaces are subjected and the time such temperature is maintained. All pathogenic organisms and many non-pathogens are destroyed in a short time if subjected to a temperature of 180° F. Steam temperature is higher than is normally required to kill most bacteria, but this does not mean that the external surfaces of a cooler, the lower section of which is filled with chilled water or brine, will be rendered sterile by the application of steam. Sterilisation of surface coolers is more easily effected if the cooling agent is withdrawn and steam is passed through the internal waterways of the apparatus. The temperature attained in this manner will destroy organisms present on external surfaces on account of the heat which metal attains. Hot water is more efficient than steam when open equipment requires to be sterilised, always provided that a minimum temperature of 180° F. is maintained for at least ten minutes. Steam is, without doubt, most suitable for use with closed vessels, and this point should always be borne in mind when cleansing operations are considered.

The routine of cleaning operations should be as follows :

(1) Immediately processing has been completed for the day cold water should be run through the plant in a similar manner to that in which milk passes through. This treatment should be repeated, using hot water to which some detergent has been added. The volume of water should be ample to ensure that all liquid milk is washed out of various parts of the apparatus and pipe-lines. The interior of holders and the surfaces of any open cooler should be well scrubbed during the time water or detergent solution is passing through.

(2) All parts which cannot be thoroughly cleansed without dismantling should next receive attention. Such parts should be taken apart and scrubbed with detergent followed by clean hot water. All pipe-lines and other small parts should then be steamed for at least ten minutes and, after steaming, should either be stored in a suitable place protected from contamination or reassembled.

(3) Filters, heat-exchangers, holders, receiving vats and tipping tanks should be well scrubbed with hot water containing detergent and finally rinsed with clean hot water. Care must be taken to remove all " milkstone " during cleansing operations.

(4) Coolers, or that portion of the heat-exchanger which is responsible for cooling milk, should receive particular attention, as lack of sterility here will result in re-contamination of the pasteurised product. No cooling system may be said to have been satisfactorily cleansed unless sterile water can be passed through without re-contamination.

(5) Prior to commencement of the following day's run, hot water should be run through after reassembling the plant. This will wash out the various pieces of apparatus and give the different portions preliminary warming before milk is passed through.

All filtering media should be destroyed after each day's run. By exercising great care in cleansing operations the bacterial content of the product will be materially decreased and the value of treated milk consequently improved.

In dealing with the cleansing of pasteurisation plant it is necessary to mention the formation of *milkstone*. Once formed and allowed to accumulate, this is extremely difficult to remove. Milkstone is composed of the milk fat, protein and mineral matter whilst it is also possible that the precipitate which forms in the softening process of hard water by detergent also becomes embedded in the mixture. After processing is completed a film of milk usually remains on the inside surfaces of apparatus. This precipitate is sticky or gummy when first deposited, and can be removed quite simply with detergent solution at a temperature not exceeding 110° F. Any temperature above this is likely to increase the adhesiveness of the material with increasing difficulty in removal. To prevent formation of milkstone, the following suggestions are recommended :

(*a*) Employ a low-temperature heating medium which should not exceed 148° to 155° F. This, of course, applies to the low-temperature process only.

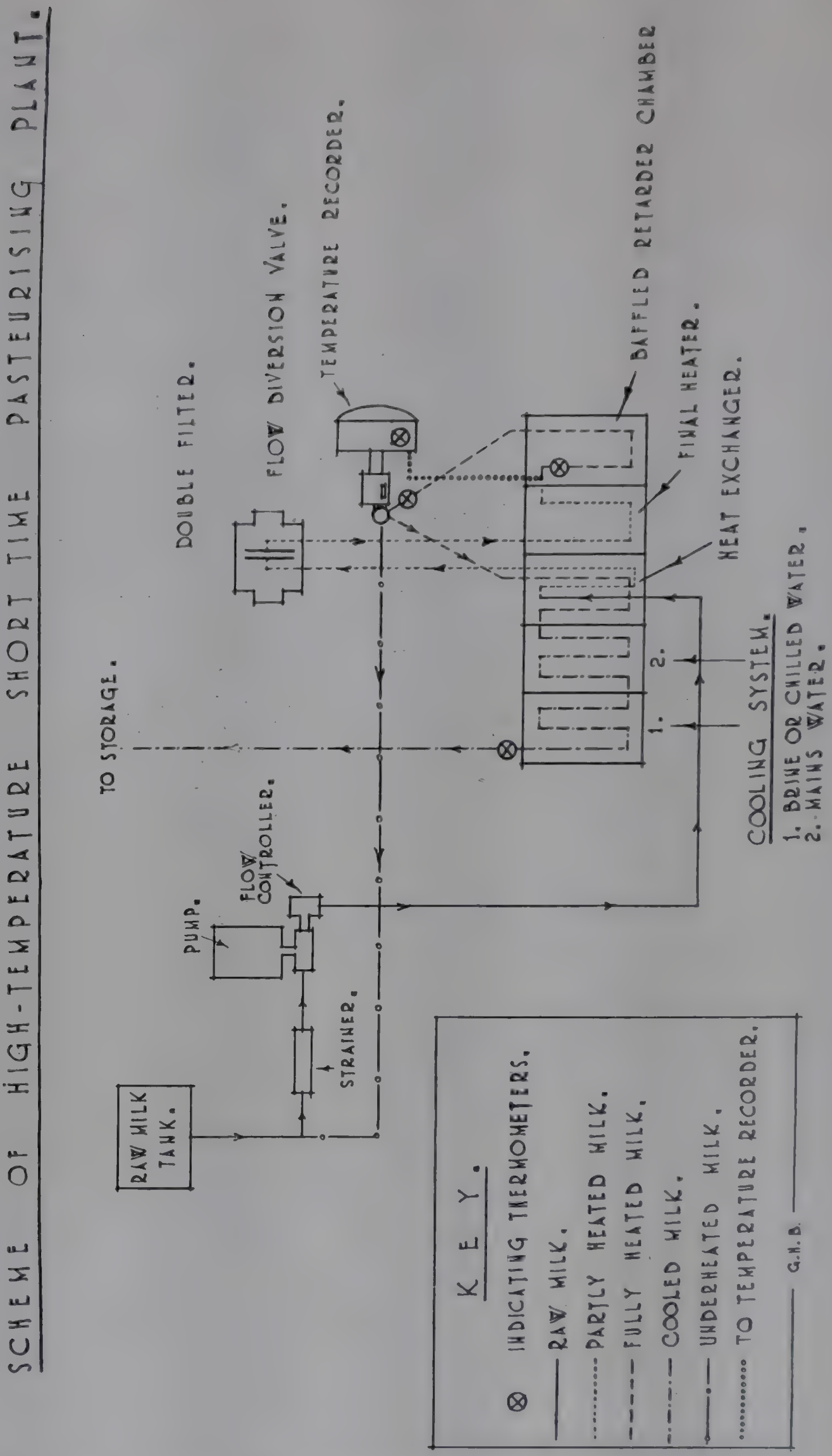

SCHEME OF HIGH-TEMPERATURE SHORT TIME PASTEURISING PLANT.
RAW MILK TANK.
STRAINER.
PUMP.
FLOW CONTROLLER.
TO STORAGE.
DOUBLE FILTER.
FLOW DIVERSION VALVE.
TEMPERATURE RECORDER.
BAFFLED RETARDER CHAMBER
FINAL HEATER.
HEAT EXCHANGER.
1.
2.
COOLING SYSTEM.
1. BRINE OR CHILLED WATER.
2. MAINS WATER.
KEY.
⊗ INDICATING THERMOMETERS.
RAW MILK.
PARTLY HEATED MILK.
FULLY HEATED MILK.
COOLED MILK.
UNDERHEATED MILK.
TO TEMPERATURE RECORDER.
G.H.B.

FIG. 178.

(*b*) Cool the system with cold water after processing.

(*c*) Use an alkaline detergent which, when softening hard water, does not produce a granular precipitate which settles quickly and has a tendency to adhere to equipment. One which rinses easily from the vat should always be employed.

(*d*) Temperature of the washing solution should be approximately 110° F.

(*e*) Rinse equipment with cool water immediately after washing is completed.

After all sections of the processing plant have received proper cleansing, the walls and floors of various rooms must not be overlooked. These should receive treatment immediately other duties are finished.

Sodium hypochlorite solutions may be employed for cleansing purposes. The employment of this type of sterilising agent has already been discussed on pages 140 to 142.

High-temperature, Short-time Pasteurisation

There are certain obvious disadvantages to the low-temperature method of pasteurisation, which in some quarters are held to render the method uneconomical from the viewpoint of the distributor. These alleged disadvantages are:

(1) Low-temperature plants to provide continuous processing require considerable space to install particularly if they have to treat large quantities of milk.

(2) Labour for, efficient maintenance and cleansing is expensive.

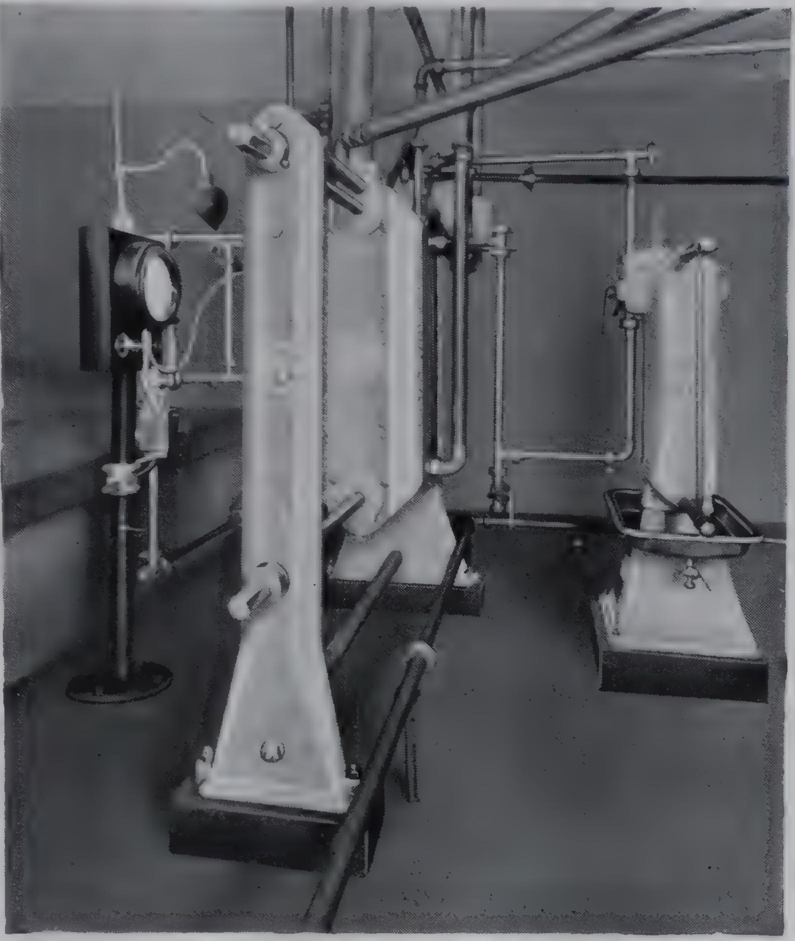
(3) Volume of ingoing and outgoing milk must be balanced.

(4) Length of run in large plants has, in many instances, to be considerably reduced owing to growth of thermophilic organisms.

(5) Considerable time is wasted while plant is stopped for cleansing operations.

For these reasons innumerable experiments have been made to elaborate a system which will eliminate these disadvantages while, at the same time, ensuring efficient treatment of the product.

The old "Flash" method of pasteurisation, condemned in 1923, was quick but uncertain, and experiments have been carried out for some time with a modified form of this system which has been designated the "*High-temperature, Short-time*" process. The Aluminium Plant and Vessel Company have achieved considerable success with this method, of which they were pioneers.



By courtesy of the Aluminium Plant and Vessel Co., Ltd.

FIG. 179. A.P.V. H.T.S.T. Pasteurising Apparatus.

As a result of their experiments they found that, at a temperature of 160-162° F. with a holding period of twelve to twenty seconds, it was possible to kill all pathogenic bacteria which milk may contain They claimed certain additional advantages for the system, as follows:

(1) Being a continuous process, there is no waste of time and milk can be bottled within a few minutes of entering the plant.

(2) This type of apparatus occupies only a fraction of the floor space required for a continuous processing plant of the low-temperature type of similar capacity. Holding vats and separate coolers are unnecessary, while innumerable inter connecting pipe-lines and balance tanks are not required.

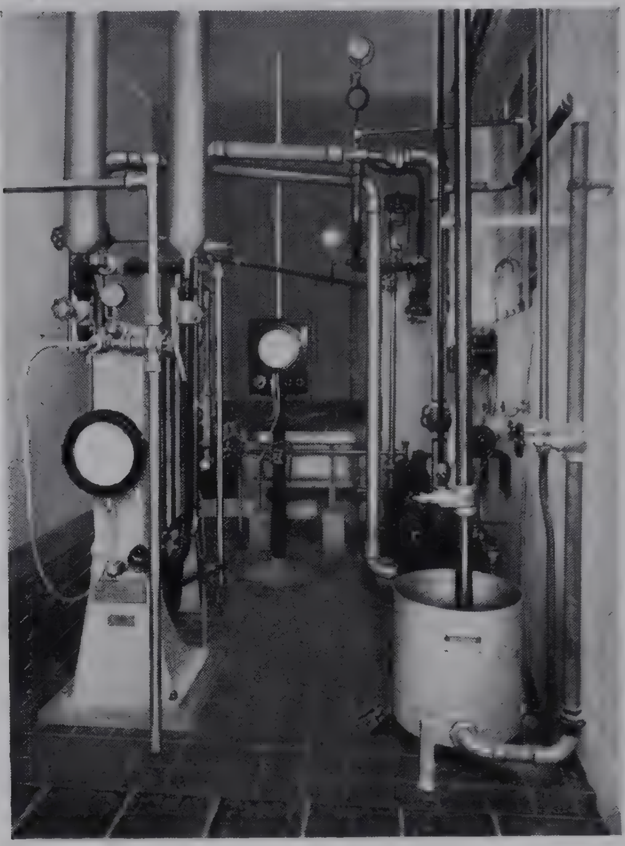
(3) There is much less likelihood of the growth of thermophilic organisms during long runs, provided that plant is not used for the treatment of raw milk possessing high bacterial counts.

(4) The plate type of high-temperature apparatus is easily cleansed, labour can be more effectively utilised, while sterilisation is facilitated by pumping hot water and steam through the system.

(5) No balancing of ingoing and outgoing milk is necessary.

(6) There is considerable saving in running expenses together with economy in fuel and water.

On these grounds alone, the system is deserving of serious consideration and the cost is certainly no greater than that of the usual type of low-temperature plant. The apparatus is usually designed on the lines of a plate heat-exchanger, capacity being increased by the addition of further sections. This type of equipment is eminently suitable for regeneration, as outgoing hot milk is quickly available for increasing the temperature of cold milk entering the apparatus. With the low-temperature system, hot milk cannot be used for regenerative purposes until fully thirty minutes have elapsed.



By courtesy of the Aluminium Plant and Vessel Co., Ltd.

FIG. 180. A.P.V. H.T.S.T. Pasteurising Apparatus.

There is, however, the public health aspect of the question to be considered, i.e. the destruction of any harmful bacteria. In this respect, experiments are now sufficiently advanced to enable it to be stated definitely that the method is equal to the previously accepted method of pasteurising milk. The conclusions reached may be summarised as follows :

(1) All pathogenic organisms in milk are killed if the liquid is held at a temperature of 160° F. for fifteen seconds. The Department of Health of the State of Pennsylvania, U.S.A., appointed a Committee to investigate this type of plant. This Committee found that :

(*a*) Of 152 guinea-pigs injected with milk treated in this manner, which had been previously inoculated with tubercle bacilli, none developed tuberculosis. Guinea-pigs were inoculated with raw milk which had been previously infected with from 7·5 to 9 million tubercle bacilli per millilitre, and every one died.

(*b*) Similar tests were made with milk infected with *hæmolytic streptococci*. Prior to treatment the milk contained 4·6 to 8·3 millions of such organisms per millilitre. After processing, streptococci were absent in the 30 tests made.

(*c*) Coliform organisms were not found in 10 ml. of treated milk.

Experiments on these lines have also been carried out by the National Institute for Research in Dairying, Reading, in which virulent tubercle bacilli and pathogenic streptococci were added to milk in large numbers. None were discovered in treated milk by animal inoculation or by other methods. Experiments in which milk naturally infected with tubercle bacilli was used also gave negative results. The most conclusive test for the efficiency of all pasteurising processes is the destruction of the enzyme phosphatase which is normally present in all raw milk. Kay and Neave have demonstrated that all common pathogenic organisms likely to be present are destroyed more quickly at the temperatures employed than is phosphatase and that this enzyme is entirely destroyed by this method of processing if properly carried out.

(2) As regards non-pathogenic organisms, various experiments carried out show that the bacterial content per millilitre of milk after treatment by this method may be *higher* than that of milk to which the low-temperature holding process has been properly applied. In countries such as the United States of America which have adopted this system, raw milk prior to treatment generally possesses a low bacterial content. Experiments show that a raw milk supply of low bacterial content is essential if such milk is to be successfully treated. In a country where all milk produced possesses a low bacterial content, the method will be satisfactory, as in such cases pasteurisation is required solely as a means of improving the keeping quality of milk and for the destruction of any pathogenic bacteria which might be present. It may be that raw milk at certain times contains organisms which are not readily destroyed by this method, although it is also possible that higher counts may be due to fluctuations in operation of the plant. As various experimenters have invariably pointed out, this type of plant has to operate with a very small margin of safety which is guarded by mechanical safeguards, and it is quite possible that this safety margin is occasionally overstepped, with the result that higher counts occur than would be the case after treatment of milk by the low-temperature process. Such increases which do occur are not sufficient to warrant the prohibition of this method of processing.

(3) From a public health point of view, no method of pasteurisation can be considered satisfactory if the nutritive value of milk is impaired. Investigations on these lines carried out up to the present, including reports from the Continent and United States of America, relating to milk treated by this method, imply that no difference in food value can be detected when the product is compared with milk which has been treated by the low-temperature method. Further experiments will no doubt be made, but there appears to be little doubt that the nutritive value of milk will be little altered if the process is efficiently carried out.

(4) There appears to be no alteration in the taste of milk when treated in this manner, nor does the process affect the odour.

(5) The importance of a satisfactory cream-line must not be overlooked, as the customer demands this evidence of quality in milk. Cream-line will not be damaged if strict care is taken in processing, and if the small margin of safety is not overstepped. Experiments tend to show that the more rapid the rate of heating to the holding temperature, the less is the effect on cream-line and probably on other nutritive properties of milk.

(6) It is natural that, with a reduction of bacterial content, the keeping quality of the milk should be considerably improved.

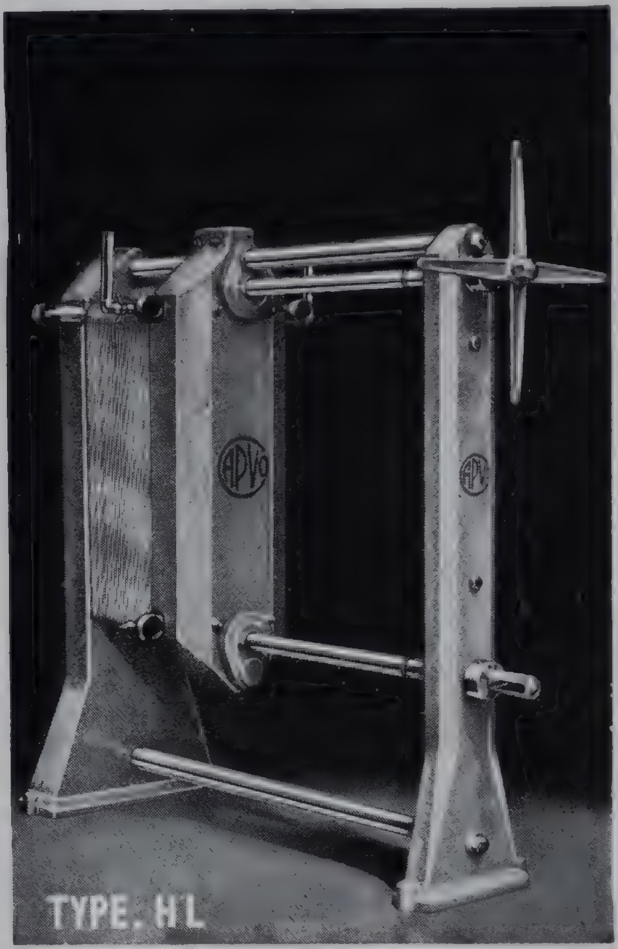
Although thermophilic organisms do not develop to any great extent during the process, it is essential that the plant should be efficiently cleansed and sterilised, while it is also essential that the first flow of partially-pasteurised milk should be drawn off before it reaches the primary cooling section of the plant. If this is not done, an infection by thermophiles may occur in the cooling sections. A point in favour of high-temperature, short-time pasteurisers is the fact that they can be readily opened up for inspection purposes and can be easily cleansed after each run. Thermoduric bacteria are not destroyed and may be a source of trouble if any attempt is made to treat milk containing large numbers of such organisms.

Several types of plant have been designed and produced for treating milk by this method. The prime essentials of any type are :

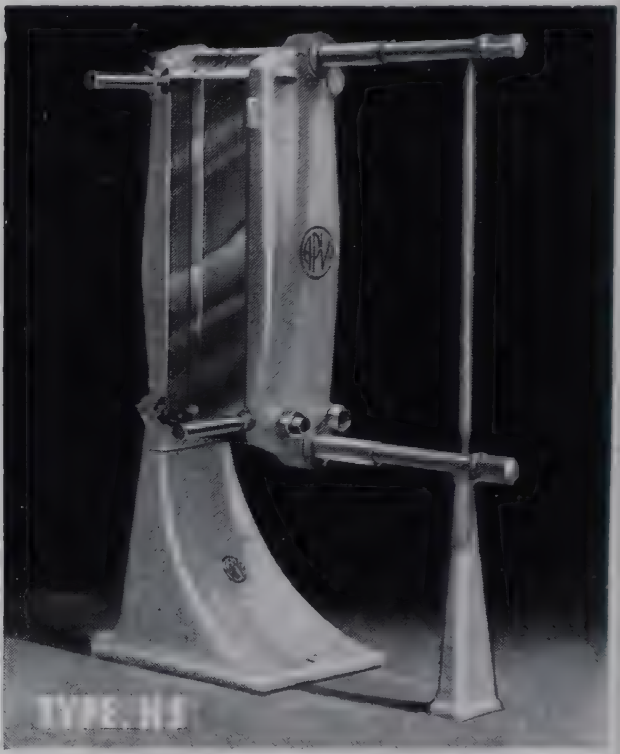
(1) Adequate heating surface in the heat-exchanger.
(2) Correct milk-to-water circulation ratio.
(3) Sensitive and accurate temperature controlling devices.
(4) Constant speed pump for circulating the milk.
(5) Accurate flow-diversion device.

As the temperature at which milk is held or retarded must be not less than 162° F., the liquid must receive a primary heating to at least 163° F. if the retarding temperature is not to fall below the limit allowed. It must be remembered that damage to cream-line and the chemical constituents of milk progressively increases as the temperature is raised above this limit.

The *A.P.V. Short-time Pasteuriser* consists of a four-section standard plate heat-exchanger similar to that already described on pages 300 to 302, with the addition of a special holding section. Capacities range from 110 gallons per hour upwards, according to the number of plates employed. Milk is pumped from the tipping tank by means of a centrifugal pump, through a flow controller to the regenerative section of the heat-exchanger, where it is pre-heated sufficiently to allow effective filtration. The liquid then returns to the heater, where its temperature is raised to approximately 163° F., finally entering the holding or retarding portion of the apparatus at whose inlet is located the bulb of a combined temperature recorder and flow-diversion valve controller, together with an indicating thermometer. The holding or retarding section is fitted with perforated baffle plates, which cause the flow of milk to be retarded so that its passage through this portion of the apparatus takes not less than fifteen seconds. At the end of this period, the milk passes through the flow diversion valve and back through the regenerative, water- and brine-cooling sections. The *flow controller* is designed to give steady and constant flow of milk to the apparatus, as variation in flow adversely affects the efficiency of temperature control. This is a simple, easily cleaned unit, fitted into the pipe-line. Milk enters at the base, passes

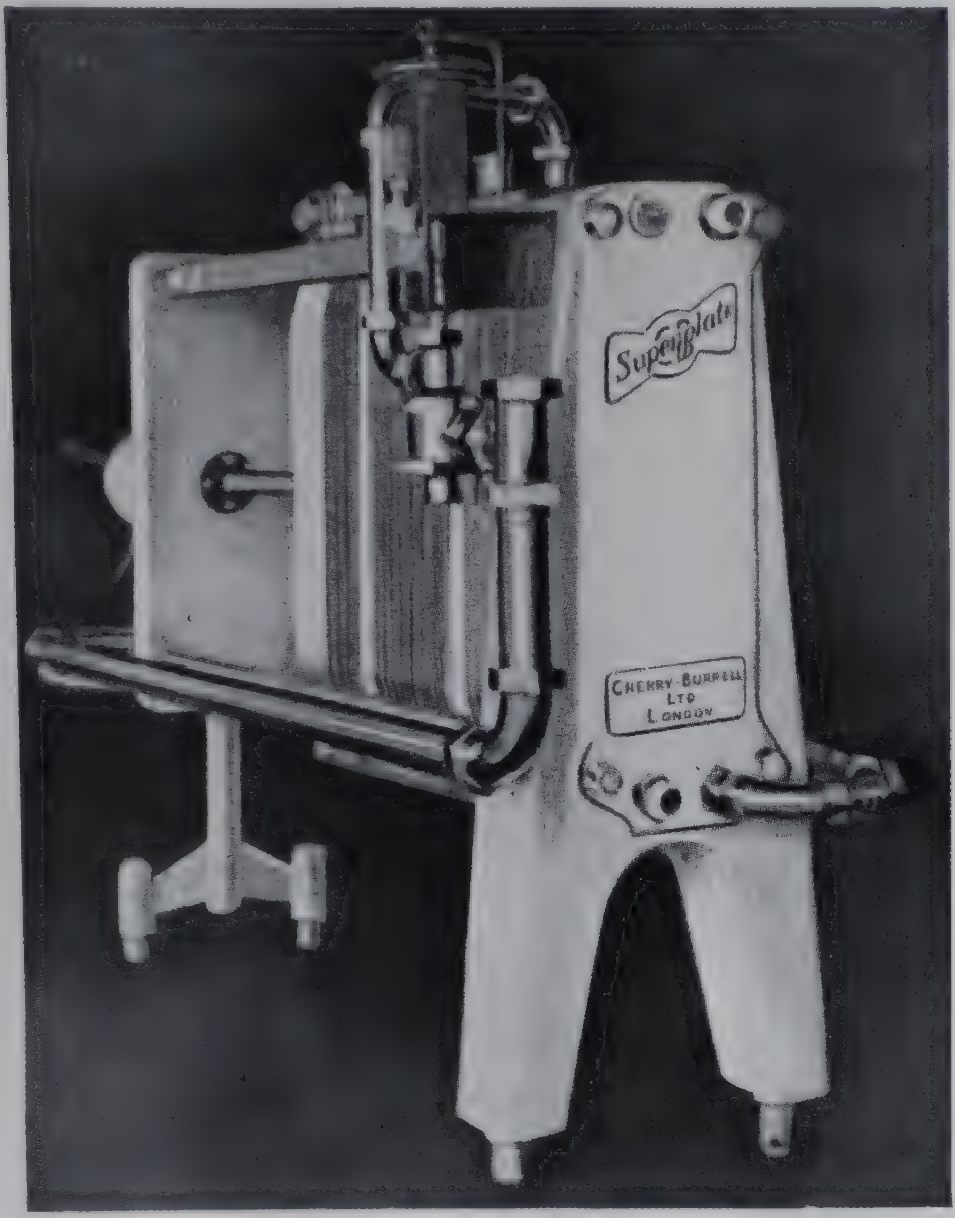


By courtesy of the Aluminium Plant and Vessel Co., Ltd.
FIG. 181. A.P.V. H.T.S.T. Apparatus.
(Capacities up to 1,500 gallons per hour.)



By courtesy of the Aluminium Plant and Vessel Co., Ltd.
FIG. 182. A.P.V. H.T.S.T. Apparatus
(Capacities up to 350 gallons per hour.)

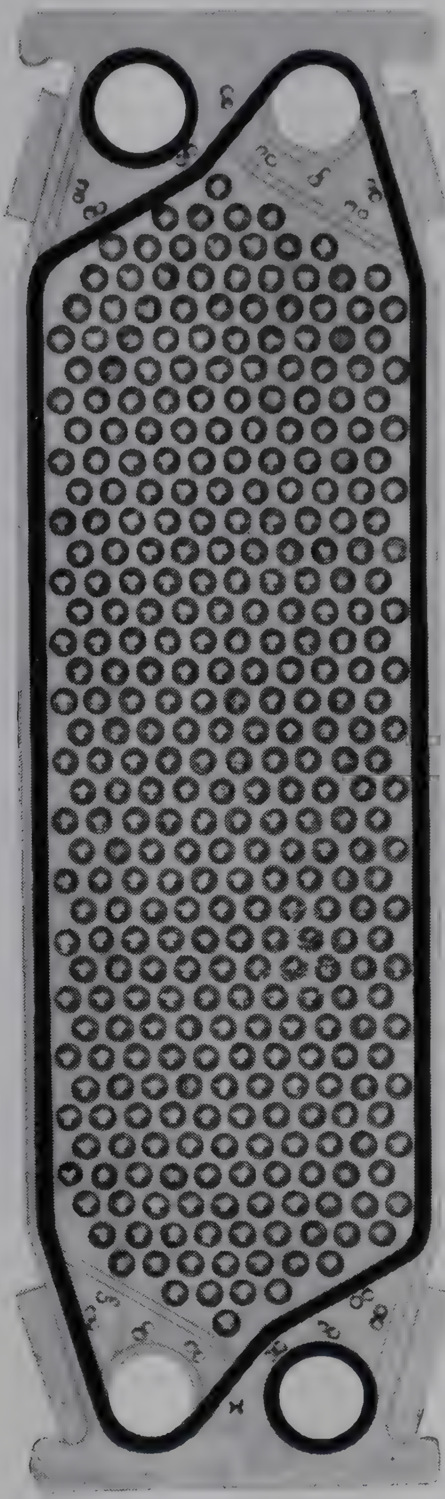
through specially shaped ports in the shell and travels upwards past a control button. When the flow increases, this button operates and reduces the size of the ports, thus restricting the flow to a predetermined level. The capacity of the unit is varied according to the size of button employed. The *flow-diversion valve* directs any sub-temperature milk back into the raw milk pipeline for further treatment. When the plant is operating normally a blue light is always visible above the temperature recorder. If the temperature of the milk at the entrance of the holding section falls, the pen arm of the thermograph moves, making a simultaneous electrical contact. This contact operates a solenoid which withdraws a pin and allows a weight to fall and the valve to open, diverting milk which is below the requisite temperature. As this valve opens, a red light appears and a warning bell informs the operator that the flow has been diverted. Automatic control is provided which prevents the operator re-setting the valve until the temperature has been re-established at the requisite level for at least thirty seconds. Hot water temperature controls are also provided.



By courtesy of Cherry-Burrell, Ltd.

FIG. 183. Cherry-Burrell H.T.S.T. Superplate Pasteurising Apparatus. Showing holder tube.

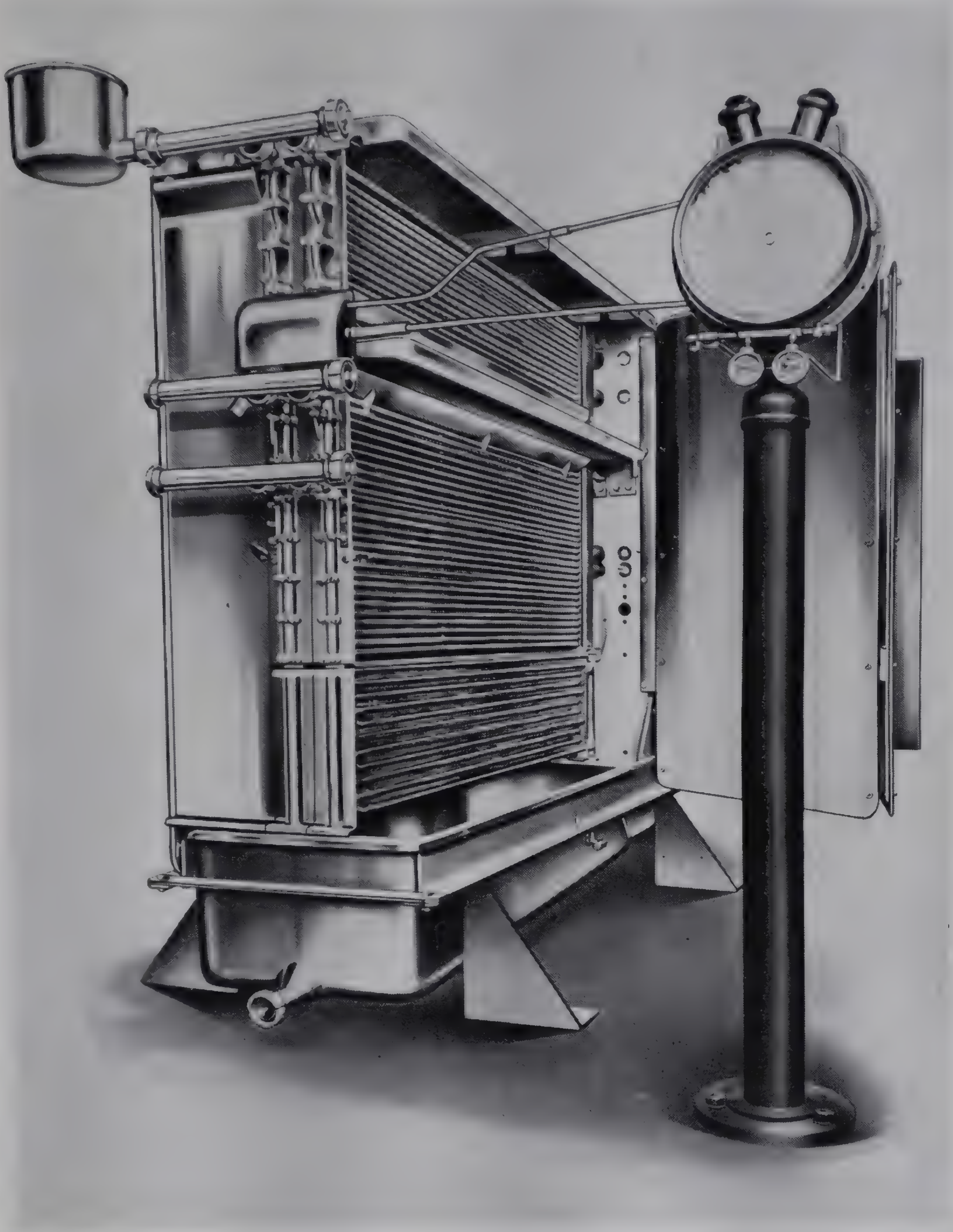
The *Cherry-Burrell* apparatus is very similar in form to the apparatus mentioned above, with certain modifications. The plates are provided with "knobs" instead of grooves, and it is an eminently satisfactory apparatus, possessing a holding tube instead of a retarding chamber. In addition to an indicating thermometer whose bulb is inserted at the final discharge point, a recording thermometer is similarly placed. This latter instrument acts as controller and operates the flow-diversion valve should the milk temperature fall. It also records the final milk temperature and shows starting, stopping and operation of the milk pump.



By courtesy of Cherry-Burrell Ltd.

FIG. 184. Cherry - Burrell H.T.S.T. Superplate Apparatus. Heat Transfer Plate.

The *Graham-Enock Short-time Pasteuriser* is an extremely novel and compact unit of unique design in which milk is processed in a film approximately $\frac{1}{100}$th inch in thickness as it flows over ingenious weir troughs. Raw milk enters the regenerative section and flows upwards, *via* a twin filter unit to the final heating section over which it is distributed by gravity. Hot water circulates through the tubes of the final heater, the surfaces of these tubes and the velocity of water passing through them being so arranged that the water temperature is only 1° F. above the required milk temperature. On leaving the heater, the milk is caught in special V-shaped troughs. These really consist of two troughs, one inside the other, with a space of $\frac{1}{8}$ inch between, the edges of the outer trough being below those of the inner trough. The base of the inner trough possesses openings of a suitable size and cannot overflow as heated milk passes out through the openings provided at the base. Milk passes through the space between the two troughs in an upward direction and flows over the edges of the outer one. A constant level is maintained in the inner trough, milk being maintained at the requisite temperature for fifteen seconds plus an adequate margin. As the inner trough is emptied from below and filled from above, there is no chance of any milk failing to receive adequate treatment. After leaving the trough the milk is collected in a distributing tank from which it flows to a flow-diversion valve. This valve is electro-pneumatically operated by a bulb placed in the outlet pipe of the final heating section. When the plant is working normally a green light is always visible on the temperature recording panel, but should the milk temperature fall, a red warning light appears, an alarm bell rings, the flow-diversion valve operates and sub-temperature milk is discharged from the plant. If working normally, milk passes through the flow-diversion valve to a distributor tray above the regenerator. Here, its temperature is reduced to 95° F. and the liquid is further cooled by mains water with final refrigerated cooling, after which it passes to a balancing tank. Temperature control is provided by means of a bulb placed in the hot milk outlet, operating through a standard recorder-controller to a steam diaphragm which causes variation in the temperature of hot water circulated. A second instrument controls and indicates the temperature of hot water, and this is placed in the hot water line, allowing injection of further steam when required. This dual control gives extreme sensitivity. The apparatus is totally enclosed, is simply opened up and easy to clean.



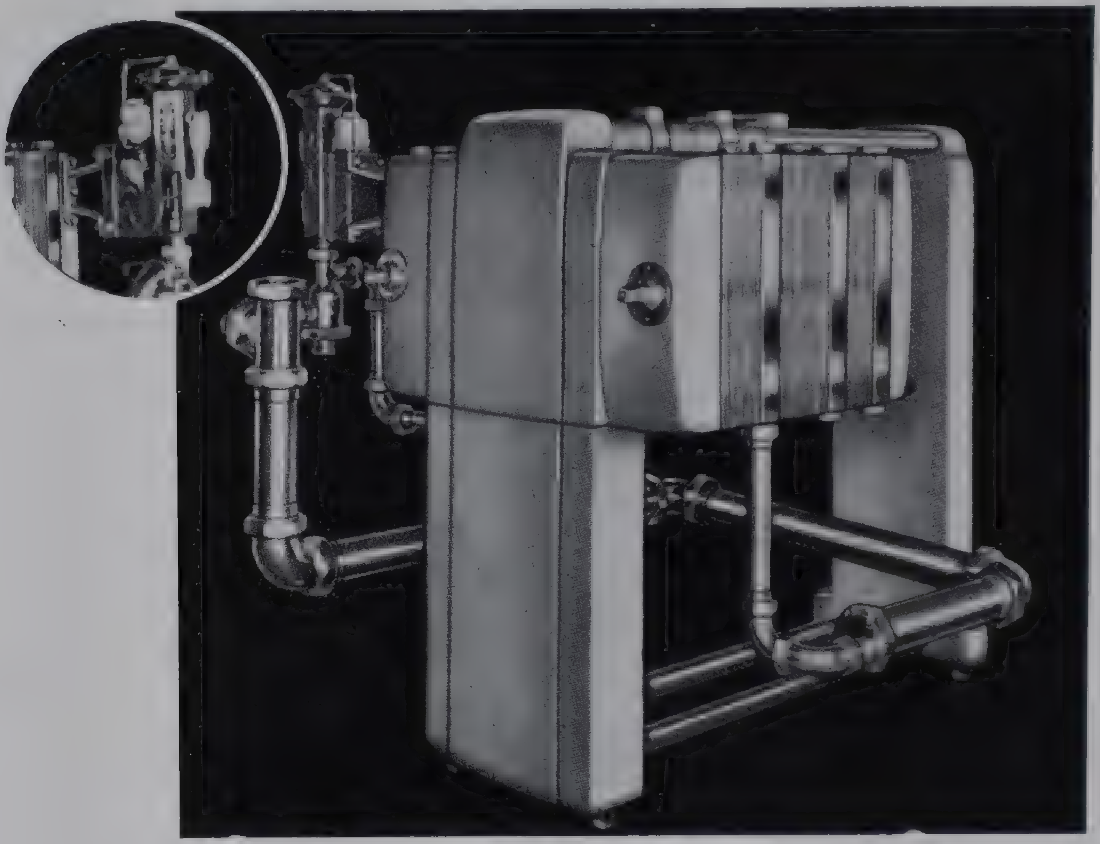
By courtesy of the Graham-Enock Mfg. Co., Ltd.

FIG. 185. "GEM" H.T.S.T. Pasteurising Apparatus. (Open.)

The *C.P. "Full-Flo" High-temperature Apparatus* is a further holding tube pasteuriser of outstanding merit. The plates are fixed horizontally instead of vertically as shown in the types illustrated above. Large quantities of milk may be efficiently handled and fully automatic and suitable temperature controls are provided.

With all short-time plant, certain difficulties may arise according to the type of apparatus concerned. Plate apparatus requires special care as regards the gasket which is fitted round each plate. As these gaskets become worn or defective, they must be replaced immediately, while special care is also needed in cleansing. When brine is used for final cooling, some loss of cooling agent is likely to result when plates are opened for cleansing, while complete drainage of milk from the system is not possible at the completion of processing. With double tube apparatus which may be employed for this form of treatment, the temperature control system is usually somewhat slower in response than it is with plate apparatus, while with both plants refrigeration costs will be higher than when low-temperature methods are employed.

The system should, however, make a special appeal to those operators wishing to process their milk economically and, now that the Ministry of Health has officially recognised this method, it may safely be applied to all dairies, irrespective of size. The small safety margin provided is sufficient to guarantee satisfactory results, always provided the greatest care is exercised, but the automatic controls which are fitted must be maintained in perfect working order and be completely reliable to ensure adequate safety at all times. It should be noted that the plate or tubular types can be readily re-converted into normal heat-exchangers for use with low-temperature plant if desired. Should compulsory pasteurisation be introduced, as appears likely in certain specified areas, plant of this type will, in all probability, be accepted as complying with any Order dealing with the matter.



By courtesy of the Creamery Package Co., Ltd.

FIG. 186. C.P. H.T.S.T. Pasteuriser. (Showing holder tube and (inset) flow diversion valve.)

The process has been recognised for some time in the United States of America by various Public Health Departments as a suitable method of pasteurising milk, but such recognition has been accompanied by the proviso that all milk so treated must be heated to a temperature of 160° F. for not less than fifteen seconds in order to secure an adequate safety margin. It will be seen that the safety margin in this country is rather greater than this.

Suitable and satisfactory control devices of extreme sensitivity and giving a speedy response to any changes in temperature are essential. A constant water temperature is a prime essential for heating milk to the required temperature and a steam-control valve, set to maintain a constant pressure of steam for heating purposes, should be fitted. This valve governs the temperature of incoming hot water, thus maintaining the final temperature of milk. The control is operated by the heating water, and, if water temperature remains steady, outgoing milk will leave the apparatus at constant temperature.

A milk temperature controller which is a vital fitment, should preferably be fixed at the inlet to the retarding portion of the apparatus, and this operates the flow-diversion valve which diverts the flow of milk for re-treatment, temperature drop and frequency of such diversions being recorded on the chart. It would be advisable to fix a recording and an indicating thermometer at the outlet of the holding section, but in this country milk temperature is usually controlled by the temperature of ingoing milk as it leaves the final heating stage. The siting of the recorder bulb at this point is of considerable importance. With apparatus of this type there is a time lag and several seconds may elapse before the mechanism will operate. Should the temperature fall, such milk could be well on its way through the holding section before diversion could take place and a quantity of under-heated milk could be passed through. In American practice, the temperature of milk as it leaves the holding section operates the flow-diversion valve. Practically, it will be found that any time lag of the controller bulb placed at this point must be extremely short. With supersensitive instruments, the flow-diversion valve could be operated from this point. The valve should never reopen before thirty seconds have elapsed, following a return of the temperature to normal.

The recorder at the inlet to the holding section is important. The pointer must be set at the required diversion temperature and should be maintained in correct adjustment. A close watch must be kept on the relationship between the temperature recorded by the pen and that shown by the indicating thermometer, also fixed at this point. It is preferable that an additional pen should be fitted to show the extent of any milk diversion. All thermometers should be frequently examined. It should be noted that while provision is usually made for the diversion of under-heated milk, any increase in temperature which may occur is liable to be overlooked. Such increase, if allowed to occur, will damage the final product, will cause milk to become cooked on the plates or inner surfaces of the apparatus, and necessitate increased labour for cleansing and sterilisation.

The introduction during the war of the High-temperature Short-time process has brought about radical changes in milk processing together with differences of opinion as to its efficacy. In spite of this, many distributors would no doubt welcome the opportunity of being able to treat milk in this manner if the process could be carried out in the bottles. Mr. A. G. Enock has undertaken prolonged investigation into the feasibility of adapting this method of treatment to milk in bottles and, following extended trials, has produced preliminary designs for commercial installations which will no doubt be available following the termination of hostilities when conditions become more settled. The high temperature (162°–163° F.) of the hot bottles when filled renders crating by human hands impracticable and an automatic apparatus has been designed which picks up bottles and conveys them after processing through a cooling bath which, by means of mains water, reduces their temperatures so that they may be re-crated by hand before final cooling takes place. It is hoped that plants for treating milk in bottles by this method may eventually be available for dealing with between 300 to 30,000 gallons per day.

Control of Pasteurising Plants by the Public Health Official

The control of pasteurisation can be divided into two distinct parts, each of which is complementary to the other. These are inspection of plant and methods, details of which follow, and laboratory control so essential to determine efficiency, which is dealt with in Chapter X.

While considerable attention has been paid to the process of pasteurisation from the point of view of safety of milk and from a nutritional standpoint, the technical aspect of the process has failed to receive the attention which it deserves. Public health officials have to exercise certain functions with regard to pasteurisation of milk. For this reason it is important that they should possess a sound practical knowledge of the technical aspect of the process and should be able to discuss the working of the plant on equal terms with the owner.

Not only is there an existing lack of such knowledge among many public health officials but, what is perhaps more remarkable, there is a serious lack of proper appreciation of the principles involved in pasteurisation on the part of persons owning and maintaining such plants. This lack of knowledge is remarkable when one considers the number of classes dealing with technique of milk processing which are held at Technical Colleges throughout the country. This number is rapidly increasing and no owner or operative should be able to process milk without some certificate of competency following attendance at a course of this type. Indeed, before a licence to operate a plant is granted, it would be advisable if the operator himself had to hold a licence to prove that he was qualified to supervise the method of processing employed. The large firms are fully alive to their responsibilities and are almost invariably progressive. Among the small distributors, however, there is not always sufficient understanding of the essentials of efficient pasteurisation, and it is to the public health official that such persons most often look for guidance.

Lack of efficiency and want of care have caused endless trouble in the past, and have provided arguments for critics to use against the process. Such carelessness is not generally wilful and may not always be the fault of the owner of the plant or his operatives. In many instances, the apparatus employed is far from satisfactory, attempts at combining different types having led to insurmountable difficulties. Some of the most serious trouble occurs through re-contamination of milk after it has received efficient treatment, a point not sufficiently realised.

It is to be regretted that all pasteurisation is not efficient, especially the so-called "commercial" pasteurisation, which is often used as a means of improving the keeping quality of milk. There is indeed far too much "commercial" pasteurisation of milk in this country. Stricter control of such plants is necessary if all pasteurisation is to be efficient, and if the public is to be able to place any reliance upon the method. Efficient pasteurisation will kill the bacillus of tuberculosis, but, with inefficient treatment, this organism is not destroyed, due to fluctuations in temperature, mechanical defects in plant and inadequate holding at a temperature lower than is essential, with a view to preserving cream-line. Furthermore, many plants producing so-called "pasteurised" milk have been found to be inefficient on inspection by officials of the Ministry of Health. Sir George Newman makes reference to this in his Report for the year 1931. The principal defects found were:

1. Unsuitable premises with inadequate protection from outside dust.
2. Apparatus of unsatisfactory design.
3. Insufficient insulation of holders.
4. Exposure of milk to contaminated air after treatment.

In some cases temperature control was inefficient, and in one case, where milk was produced under licence, no thermometer of any kind was fitted.

The Report of the Cattle Diseases Committee of the Economic Advisory Council, published in 1934, recommended that only officially approved plants should be employed for the pasteurisation of milk and that all plants on erection should be tested to ensure that they complied with the approved design. It was emphasised that frequent inspections under working conditions were necessary and that inspectors should apply certain prescribed tests, recording the results of such inspections and tests at each visit.

Dalrymple-Champneys has published a series of points for the guidance of officials investigating the efficiency of low-temperature pasteurising plants in the form of question and answer and some of these queries apply equally well to High-temperature Short-time apparatus. As they form an excellent *résumé* of the essential details of such an investigation, they are herewith set out in full:

"(1) Is the raw milk before treatment reasonably clean?

"Pasteurisation does not sterilise milk, nor does it make dirty milk clean, but merely reduces very considerably the number of organisms. It is essential that the process should only be employed for the treatment of raw milk possessing a low bacterial content.

"(2) Is the apparatus efficiently sterilised and cleansed after each day's work?

"In this connection the inspector is warned not to accept vague statements that all the pipes are cleaned out with brushes and then sterilised by steam. Certain enquiries should be made as to:

(*a*) How the brushes are cleaned.
(*b*) Where the brushes are kept after cleansing.
(*c*) How steam is applied afterwards.
(*d*) Length of time during which steam is applied.

"(3) How is the temperature of the milk determined during the holding process so as to make sure that the *whole* of the milk has been kept at a temperature of 145° to 150° F. for not less than thirty minutes?

"It is pointed out that it is practically impossible to design any temperature recorder that will give the true temperature of every portion of a large bulk of milk during the holding period. Such attempts would fail and heavy expense would ensue. This difficulty is overcome by installing a reliable instrument so as to record the temperature of milk when it leaves the holder, when the passage of a small quantity of insufficiently-heated milk is quickly detected. It is recommended that the recorder should be placed where it can be easily seen.

All temperature indicating instruments should be tested at frequent intervals.

"(4) How is the holding time regulated?

"If this is done by mechanical means, the efficiency of such mechanisms needs periodical checking.

"(5) Is the holder efficiently insulated or otherwise protected from heat loss?

"If this is not done, milk must suffer a drop in temperature before the end of the holding period is reached or it has to be overheated before entering the holder.

"(6) Does any portion of the milk lie outside the holding zone during the half-hour of treatment?

"This is a common fault of many of the older plants, and a small quantity of insufficiently-heated milk can raise the bacterial count of a large batch of milk above the statutory maximum. This may occur with any foam that may form on the surface of milk which, in a badly constructed holder, often escapes adequate heating and so contaminates the remainder of the liquid.

"(7) Is there any possibility of *forward* leakage in the system, so that unpasteurised milk may gain access to any milk in the holder during the holding period, or may escape forward from the holder during the holding period, and which may contaminate the milk already passed forward or, later, the milk behind?

"It is pointed out that backward leakage of milk is of minor importance. Any leakage should, of course, run to waste.

"(8) Is the milk protected from contamination during the cooling process?

"Many open coolers are still to be found. The protection of milk during cooling is particularly important, as owing to the destruction of almost all the lactic acid bacilli, extraneous organisms introduced at this stage have special opportunities for development.

"(9) Is the milk protected from contamination during the filling process?

"In an efficient plant, filled bottles should be uncovered for a minimum of time before capping.

"(10) Are the bottles efficiently cleansed before being put into use again?

"A bottle may be quite clean and bright in appearance, but may have numerous micro-organisms adhering to its inner surface."

More complete guidance for public health officials concerned with the supervision of pasteurising processes has also been supplied by the Ministry of Health, which has issued a further report of Dalrymple-Champneys, dealing with this question. It is pointed out that, although an inspector may be expected to criticise, such criticism should be as constructive as possible. The following points [1] are enumerated as requiring the attention of the inspector:

Construction of Buildings

Sufficient floor space.
Sufficient air space.
Efficient ventilation.
Good lighting

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[1] Reproduced by permission of the Controller of His Majesty's Stationery Office from *Reports on Public Health and Medical Subjects*, No 77, 1635. "Reports on the Supervision of Milk Pasteurising Plants."

Freedom from dust and fumes.

Good roof—no dust traps.

Walls sound and easily cleansed—if limewashed, this should be carried out every six months.

Floor sound, impervious, and well drained.

General cleanliness.

Lay-out

Economy of space without overcrowding.

Room for operation, cleaning (including dismantling), and supervision of plant.

Thermometers to be placed where easily read.

Components of Pasteurising Plant

(1) *Tipping Tanks.*

Protection from dust, oil on machinery, etc.

Cleanliness of tank, stirrers, can rack, strainers, etc.

(2) *Milk Pumps.*

Cleanliness.

Tight joints—no frothing.

No glands or stuffing boxes in contact with milk.

(3) *Filter.*

Cleanliness of filter and filter-cloths.

Frequent changing of filter-cloths.

Avoidance of excessive pressure in filtration.

(4) *Heater.*

Cleanliness.

Complete separation of milk from hot water or pasteurised milk (if heat-exchanger).

Temperature control—fixed thermometer and thermograph (if possible)—temperature of whole of issuing milk to be between 145° and 150° F. If very near 145° F., careful checking of pasteurised milk called for.

(5) *Holder.*

Cleanliness.

Protection of milk from dirt—absence of milk pools on top of cover, efficient insulation—if cover or whole of walls not insulated particular attention to be paid to the temperature of pasteurised milk.

No glands or stuffing boxes in contact with the milk.

Efficiency of inlet and outlet valves—drip from outlet valves (if any) must not come into contact with the issuing pasteurised milk.

Accuracy of timing mechanism operating valves.

Absence of " dead-ends " (" cold pockets ").

Absence of undue foam on the surface of milk in the holder. All possible precautions to ensure that foam is kept at pasteurising temperature.

Complete separation of the milk in the different compartments of the holder, both during the holding period and during inflow and outflow. Prevention of overflow from one compartment of holder to another.

Accuracy of thermometers and temperature recorders—properly placed. Charts of recorders to be on sufficiently large scale and to be secured from tampering. Separate recorders for independent tanks of " Batch " pasteurisers.

Temperature of pasteurised milk to be between 145° F. and 150° F.

If holder discharges into balancing tank, must have a good cover, and foam must not be able to get back from this cover into the tank.

If holder is of vacuum type, air supply to compressor must be filtered.

Thorough warming up of holder with hot water before being used for milk.

(6) *Cooler.*

Cleanliness.

Protection from dust, etc.

Complete separation of the milk from cooling media, including cold raw milk.

(7) *Pipe-lines.*

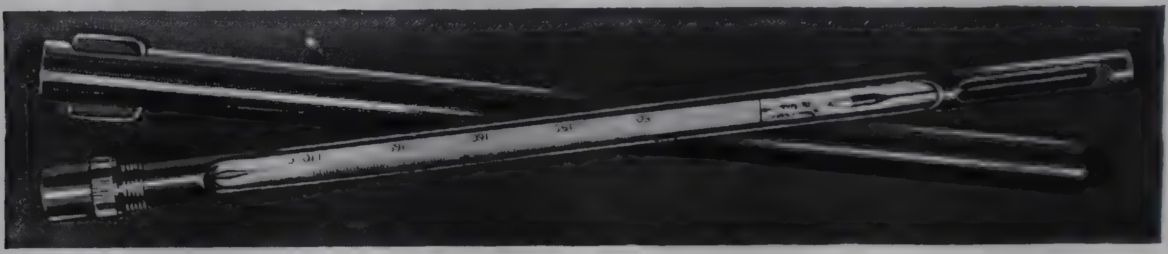
Cleanliness.

Completely separate lines (including valves) used for raw and for pasteurised milk.

(8) *Balancing Tanks.*
- Cleanliness of tank and agitating gear (if any).
- No soldered joints.
- Separate tanks for raw and pasteurised milk.
- No glands or stuffing boxes in contact with the milk.

In the above list of points, the public health official has been given a complete form of guidance for the inspection of any pasteurising plant and particularly those treating milk by the low-temperature method, with a view to the correction of any faults which may arise. It should be added that, while the inspector should insist upon the routine treatment of milk and the cleanliness of plant being strictly observed, the closest co-operation should exist between the distributor and himself on all points, to ensure that the customer obtains a satisfactory article.

The *temperature* to which milk is heated and subsequently cooled is of vital importance, and this has already received repeated emphasis. It is often found that employees do not fully realise the importance or necessity for correct temperature maintenance. Inspectors should be on the look-out for any intentional reduction in holding periods as a means of providing speedy treatment, which is usually due to the necessity of obtaining an increased output from an inadequate plant, while indicating and recording thermometers may not be accurate. It is important that all indicating thermometers should be checked at least once monthly, a standard thermometer reading to within 0·2° F. being employed for the purpose.



By courtesy of Negretti and Zambra.

FIG. 187. Dairy Test Thermometer.

This is extremely important as the Ministry of Health have recommended that the accuracy of heating thermometers shall be ± 0·2° F. between temperatures of 145° and 150° F. They emphasise also that thermometers used for testing shall have been certified by the National Physical Laboratory. The Negretti and Zambra dairy test thermometer, illustrated in Fig. 187, has been designed to comply with the above-mentioned requirements. This instrument is 10 inches in length and possesses a range of 140° to 155° F. with widely spaced divisions so that readings to 0·2° F. can be quite simply made. It will withstand high temperatures and is certified by the National Physical Laboratory, who issue a certificate of correction with each one.

The time-lag of all plant thermometers should be checked by inserting them in a water bath at 160° F. The time required for the reading to rise from 140° to 155° F. should not be more than four seconds. Plant thermometers and recorders may be tested by immersing their bulbs in a pail containing not less than three gallons of hot water, the temperature of which should be approximately 150° F. Care must be taken to ensure that their bulbs do not touch the side of the pail. The test thermometer is inserted to a depth of 3 inches, the water being circulated throughout the entire operation, until a steady reading is indicated by all instruments. The temperatures indicated by the thermometers to be tested and by the testing thermometer are noted, the operation being repeated until constant relationship is exhibited. Any difference should be noted, and in the case of recording instruments, adjustments should be made for their correction, while a differential correction is necessary for indicating thermometers. Indicating thermometers should always be used to check temperatures under working conditions and careful comparisons between the temperatures shown and those indicated by the recorder should be made. At no time should the temperature recorded be higher than that shown by the indicating thermometer, with a deviation of not more than 1° F.

Temperature recorders require periodical checking, and they should be kept locked to prevent interference. These instruments may often be found to require re-adjustment.

The Inspection of High-Temperature Short-Time Plants

The procedure mentioned above deals with the inspection and supervision of low-temperature pasteurisation plants, apparatus dealing with milk by the short-time process requiring different treatment. On account of the small margin of safety provided, extreme care is necessary in dealing with such apparatus, and the inspector should make certain that not only does the plant operate efficiently at all times but that it has been properly installed.

Once an application has been received by a local authority for a licence to produce pasteurised milk by this process and plant installation has been completed, certain steps must be taken to ensure that the apparatus is capable of producing a satisfactory article. Before it is allowed to treat any milk for human consumption, every part of the apparatus should be examined and checked, and the inspector should be satisfied that operation is satisfactory. The approval of local authorities and their officials to the operation of such plants without prior checking is open to serious criticism, although this is a mistake which is commonly made and is often due to over-reliance on manufacturers' statements as to the efficiency of the plant and to lack of knowledge as to where faults may lie.

Before dealing with the points where careful checking is required, it is necessary to set out the items which, when *fully* and *continuously* complied with, will satisfy the inspecting official that the installation is properly fixed and operating in a satisfactory manner. These are :

(1) Recording and indicating thermometers must have been tested for time-lag and found to be accurate to within 0·2° F. between 155° and 165° F.

The method of testing both these instruments has been detailed on pages 328 and 329.

(2) The flow-diversion pen must be in perfect working condition and should record every division of milk from the forward flow to the raw milk tank or pipeline.

It may be found that the operating staff are not fully conversant with this part of the recording apparatus or its correct use.

(3) Holding period must be carefully checked and must be at least fifteen seconds.

The required method of checking is set out on page 331.

(4) The diversion adjustment must be set to divert all milk back to the raw milk balance tank, whose temperature is below 162° F.

It is essential to ensure that the cut-out works properly when the milk temperature falls below the requisite level. Any milk of reduced temperature may be drained from the valve or it may be allowed to return to the raw milk tank. Short-time plants are designed to allow milk to be returned for reprocessing, although it is a debatable point whether or not such return infringes the condition laid down in the Milk (Special Designations) Order, 1936, which states that no milk may be heated more than once. In any case, with reliable, modern apparatus, very little low-temperature milk should require to be returned.

(5) The variable speed pump must be set and sealed to ensure continuously a holding period of not less than fifteen seconds.

It should be noted that in dealing with belt-driven pumps, wear or stretching of the belt will cause variation in speed.

(6) Pressure on the pasteurised milk side of the plates in a plant of that type must at all times be greater than the pressure on the raw milk side.

At the commencement of the run water may be passed through the apparatus prior to milk being allowed to enter in order to establish a proper pressure. Sufficient head of pasteurised milk should be retained in the regenerator in order so as to maintain a milk level for one hour after the plant is shut down.

(7) Where a tube retarder is employed, the tubes should slope upwards from inlet to outlet, this slope being approximately half an inch to the foot.

Low points, except at the inlet end, tend to trap air and so shorten the retarding period. Bell type or concentric fittings should be employed at the ends of these holder tubes in order that the slope of the tube may not be improperly changed.

(8) There should be an entire absence of air or milk leaks.

Air drawn into the apparatus greatly reduces the milk capacity.

(9) There should be no forward leakage while the valve is in a diversion position.
(10) Constant head of milk should be maintained in the surge tank.
(11) If a predetermined accurate check of actual holding time is made, the measured capacity should correspond to the calculated capacity of the retarding portion of the apparatus.

If a holder chamber has a capacity of 50 lbs. of milk and the holding time as regulated by the pump is the requisite fifteen seconds, approximately 12,000 lbs. of milk per hour would be delivered. Any variation in weight of milk delivered which might be found at a subsequent test would show that the apparatus was not operating properly.

(12) Temperature control should operate smoothly, ensuring a steady flow of milk at the requisite temperature.

Frequent diversion of the milk is most undesirable.

(13) Assembly of the controlling pump should ensure that it is airtight.

Its capacity may be decreased on account of worn bearings.

(14) All draw-off openings should be accurately labelled so that the temperature of the liquid to be obtained from such openings is plainly indicated.
(15) The diversion valve should not cease to function once milk has been diverted until thirty seconds have elapsed.

Once the manufacturer has installed and tested the plant, before it is used commercially, the public health authority should be ready to make its own inspection and series of tests. The *level of any holding tubes* should be checked and adjusted where necessary, while *gaskets* should receive careful inspection so that air leaks are obviated. It would be advisable if vacuum gauges were fitted at different points in the system to detect such leaks should they develop. The *accuracy* of thermometers is of extreme importance. An accurate test thermometer should be inserted in the apparatus at points requiring to be tested and water at a temperature of 162° F. should be circulated through the plant until the water temperature is stabilised, when the indicating thermometer fitted should be checked against the test thermometer. In addition, the recording thermometer should be tested in a similar manner, the water temperature being raised above 162° F. to prevent any diversion taking place while testing is in progress. If necessary, the recorder should receive adjustment.

The *diversion temperature* must be checked by the circulation of water at a temperature slightly above 162° F. This temperature should then be slowly reduced until the diversion point is found. If this is too high or too low, the diversion controller should be adjusted. Once the correct diversion point is found, this controller should be sealed.

The *holding time* can now be checked, sufficient water being supplied to the raw milk tank to prevent any air entering the apparatus. All plants should be supplied with suitable fitments to allow the necessary tests to be made, and before any water testing is carried out, new filter media must be installed. A small measured charge of methylene blue solution should be pumped into the holder inlet and the time taken for this solution to reach the pet cock fixed at the outlet of the retarding chamber or holding tube should be checked by means of a stop watch. It is advisable that several readings at intervals of 10, 12, 15, 20, 25 and 30 seconds should be made. A piece of white paper may be used as a background at the pet cock and the first appearance of colour should be considered the end point of the test. Another extremely accurate method is the injection of nickel ammonium sulphate solution by means of a spring-loaded injector. Dimethylglioxine is used as an indicator. A more accurate method of testing is carried out by the use of salt and a galvanometer. A high-pressure cylinder holding two quarts and fitted with an air gauge is employed, a quart of saturated salt solution being placed in the cylinder which is attached to the holding portion of the apparatus. Air is pumped in until 80 lbs. pressure is registered, and this will release approximately 20 ml. of the solution. A galvanometer whose contact points have been enlarged with light sheet copper to increase sensitivity is used. This is connected to the indicating thermometer outlet, and water, at a temperature slightly above 162° F., is circulated and salt solution injected. The time of injection and the time at which the galvanometer indicates the presence of salt are then noted. At least five tests should be made before any licence is granted, readings being taken at intervals as set out above.

The plant should be similarly tested at monthly intervals, and the product after treatment should be frequently submitted to the phosphatase test at least once weekly. It must be emphasised that this latter test alone must never be used to judge the efficiency of any short-time plant. The tests and methods of inspection outlined above are essential if satisfactory control is to be maintained and safety of the final product guaranteed.

The Advantages and Disadvantages of Pasteurisation

The advantages to be expected from efficient pasteurisation of milk may be summarised as follows:

(1) Milk is rendered "*safe*," as all *pathogenic organisms are destroyed.*
(2) The majority of *non-pathogenic bacteria are also destroyed.*
(3) *The useful life of milk is prolonged.*

The disadvantages are:

(1) *Pasteurisation cannot render Dirty Milk Clean.* The standard fixed in New York for milk prior to pasteurisation is 300,000 bacteria per millilitre. If this standard were fixed in this country, many supplies of milk would be graded as unfit for processing. A CLEAN MILK IS ONE OF THE FIRST NECESSITIES FOR EFFICIENT PASTEURISATION. Dirty raw milk contains heat-resisting organisms in abundance, and, after treatment, such milk will soon become putrid.

(2) *Pasteurisation tends to reduce Cream-line.* A temperature of 145° F. for thirty minutes injures the cream-line and 8 to 10 per cent. deduction may be expected. At 146°–148° F. for the same period, the average decrease in cream-line is 20–30 per cent. At 150° F. this decrease is 40–50 per cent. It is possible to conserve the cream-line by rapid cooling of hot milk. The critical temperatures are those between 110° and 60° F., and it is essential to cool quickly between these limits if cream-line is to be preserved. The lower the temperature to which milk is cooled, the better will be the cream-line. Chemically, however, the fat content remains unaltered.

(3) *The chemical constitution of milk is altered* in accordance with the temperatures to which it is heated between 145° and 150° F. as follows:

(*a*) Between 145° F. and 150° F. 5 per cent. of lactalbumin is precipitated.

(*b*) Equilibrium among the mineral constituents is upset.

(*c*) A proportion of calcium and phosphates contained in milk is precipitated in insoluble form, usually about 5 per cent.

(*d*) Proteins and enzymes begin to be affected at 150° F. and are entirely destroyed at high temperatures for short periods.

(*e*) Lactose is unaffected by the process.

(4) *The vitamin content of the milk is altered* in a varying degree, as follows:

Vitamin A. Not seriously influenced by pasteurisation but a slight loss has been observed by several investigators. Stassanised milk shows a smaller loss of vitamin A content than does holder-pasteurised milk, but this loss is insignificant.

Vitamin B_1. Not absolutely heat tolerant, as evidence shows that the treatment causes a reduction of between 10 to 20 per cent.

Vitamin B_2. Not affected.

Vitamin C. Heat sensitive and destroyed to a greater or lesser degree by pasteurisation according to the method employed. The amount destroyed depends upon previous exposure to light, particularly sunlight, and the degree of oxidation which takes place, this being accelerated by the catalytic action of metals. Usually, milk loses from one-fourth to one-third of its vitamin C content during the process. In this respect it should be noted that there is little catalytic action by stainless steel or metals used in the construction of modern plant. Careful handling of milk by providing protection from light and air and the use of modern plant reduces such losses considerably. High-temperature short-time pasteurisation is definitely less harmful to the vitamin C content than are low-temperature methods.

Vitamin D. Absolutely heat tolerant, at pasteurising temperatures.

Vitamin E. Not influenced so far as is known.

Except as mentioned above, the nutritive value of milk treated by the short-time process is similar to that dealt with by low-temperature pasteurisation.

(5) *The flavour* of pasteurised milk may be slightly different to that of raw milk, due to the removal by filtration and by heat of the volatile substances derived from the cow and its surroundings. This alteration is not discernible by every consumer.

From the foregoing, it would appear that the advantages of a safe, long-keeping milk considerably outweigh the so-called disadvantages, particularly as there is no evidence to show that the nutritional value of milk apart from some loss of vitamin C is materially affected.

The Need for Pasteurisation

There are two aspects to pasteurisation—the public health and commercial viewpoints. From the public health point of view the desired objects of pasteurisation are :

(1) The destruction of all pathogenic organisms contained in milk which would be likely to affect the health of the consumer.
(2) The destruction of as many non-pathogenic organisms as is possible with a view to enabling milk to reach the consumer in a sweet condition.
(3) The maintenance of nutritive value.

From the commercial aspect, pasteurisation embodies the following conditions :

(1) The process should not raise the price of the finished article above the purchasing power of the poorest consumer.
(2) Cream-line must not be affected to any great extent, since milk possessing a deep cream-line sells much better with the majority of consumers than does milk which shows a shallow cream-line.
(3) The appearance and taste of the milk should be altered as little as possible.

The existence of these separate and not always reciprocal interests has somewhat confused the issue with regard to pasteurisation, but it should be definitely understood by all concerned that the final desideratum is a *safe* milk supply within reach of at least the vast majority of the milk-consuming population.

It is often argued that, if milk were produced in a cleanly manner free from all harmful organisms, any treatment by heat would be unnecessary. This must be granted, but two factors prevent such a Utopian dream being attained, at any rate for some considerable time. The first is that, at the moment, there is no compulsion on the farmer to produce milk with a low bacterial content, free from tubercle bacilli, although the introduction of the National Milk Testing Scheme is a progressive move in the direction of cleanliness ; or neither is it necessary for him to provide for a strict clinical examination of his animals with a tuberculin test at frequent intervals, although he is encouraged to do so by monetary inducement. Even when this holds, as in the case of animals producing Tuberculin Tested milk, there still appears to be a risk, always granted that such risk is greatly mitigated by the supervision under which such herds produce milk. The second factor to be considered is the fact that quite a large proportion of the milk supply has to travel long distances before it reaches the consumer. In such circumstances some treatment by heat is necessary to maintain the product in a state suitable for human consumption.

Efficient pasteurisation is the sole means whereby the distributor is enabled to *guarantee* that his milk is free from any disease-producing organisms which may be injurious to the health of his customers. To be able to give this guarantee is an asset of no little commercial value. Further, in view of recent legal decisions, distributors must remember that should their milk be the cause of any infection, they may be liable to heavy damages by way of compensation to affected persons. That the need for this treatment exists is clearly evidenced also by details of outbreaks of various diseases caused through milk which have been detailed in Chapter II. It is also the only way in which milk can be delivered which will keep for a period in any way comparable to that which holds when customers are served with clean milk fresh from the farm immediately after production. It is not, and never can be, a process which will render dirty milk clean, or sour milk sweet, and it is essential that it should only be used in conjunction with clean milk production. Pasteurisation is not a concealer of faulty production methods. Rather does it reveal such methods, while it cannot be used with any success to assist in the distribution of dirty milk.

The need for the pasteurisation of the greater portion of our raw milk supplies is emphasised by the Report of the Research Advisory Committee of one of the largest dairy companies in the country issued some time ago. This Committee for some time had been investigating the character of its ordinary supplies of raw milk from all parts of the country, before and after pasteurisation, together with investigations into the character of Certified and Grade A (T.T.) supplies, as they were then termed, produced under licence from the Minister of Health. Some idea of the thorough manner in which these investigations were carried out may be realised when it is stated that, in some cases, the examinations involved testing the milk from each separate teat of every cow in a herd.

The results of these investigations are illuminating. As regards the ordinary raw milk supply, it was found impossible to accumulate any material quantity of milk on any day in any important milk-producing area in this country which was free from tubercle bacilli. In each of the investigations undertaken, these organisms were present before pasteurisation, but were absent after the milk had been processed.

Raw milk produced to designated standards under licence is naturally presumed to be the product of the super herds of this country. Samples of such milks examined during the same investigation, however, showed one positive and one doubtful tuberculous sample. This percentage is not very large, but, coming as it does from herds undergoing fairly frequent veterinary inspection and being tuberculin tested at regular intervals, it would appear that these are not always what they seem. Further investigation of samples of graded milk showed that 76 per cent. contained *hæmolytic* (*mastitis*) *streptococci*, and 62 per cent. the *Brucella abortus*.

Statements are often made welcoming the increased production of Accredited milk as a step towards the safety of the milk supply. Such milks are clean and suitable for pasteurisation, but their safety is very much in doubt. This must be obvious to all unbiassed persons when it is remembered that they do not possess the advantage of being derived from tuberculin-tested cattle. Consideration of the afore-mentioned results shows that even tuberculin-tested milk cannot always be guaranteed safe in every respect. It is possible, indeed, that Accredited milk may be more heavily infected with disease-producing organisms than is undesignated raw milk, while the infection of tuberculin-tested milk with *Brucella abortus* is likely to be quite as high as that of ordinary raw ungraded milk, if not higher.

It is apparently vitally necessary at the present time to treat the bulk of the country's milk supply with heat in some form or another if it is to be fit for use, and outside the two highest grades mentioned in the previous chapter all raw milk should be pasteurised. It is a known fact that statistics can be used to prove any statement, but the figures set out above were obtained as a result of practical examinations by an experienced staff, and can surely indicate nothing except the serious need for pasteurisation of the greater portion of raw milk supplied throughout the country.

Many statements are made to discredit the pasteurisation process. These generally follow certain stereotyped lines, and can be readily refuted. They are:

(1) No proof of any kind has been forthcoming that any form of tuberculosis is conveyed by milk.

Such an argument leads one to suppose that opponents of pasteurisation have not troubled to acquaint themselves with the research work carried out by various bacteriological laboratories throughout the country, not only those owned by large milk companies, but also those of various public health authorities. One instance of such investigation work has already been given and there are many others. The consensus of medical and veterinary opinion is that the organisms of tuberculosis are widespread in the raw milk supplies of the country. This being so, such milk when consumed in its raw state is liable to cause infection of the consumer. If further proof were needed as to the ravages of this disease through infected milk, Sir George Newman might be quoted. He stated, in his Report to the Minister of Health in 1933 :

" The pasteurisation of milk in accordance with the requirements of the Milk (Special Designations) Order, 1923, if carefully and properly carried out, carries with it the immense advantage of making milk SAFE for the consumer without any impairment of its nutritive properties. It is significant that the extension of the practice of pasteurisation has synchronised both in time and place with a remarkable decline in the incidence and mortality of those forms of non-pulmonary tuberculosis which are attributable to the infection of Bovine tuberculosis."

The late Lord Dawson of Penn, Lord Horder, Lord Moynihan, Sir Frederick Hobday, and Sir W. G. Savage, in a signed statement in the *Daily Telegraph* of October 17th, 1933, also stated :

" Raw milk as at present distributed for human consumption shows an average presence of living tubercle bacilli. Two thousand children die annually from tuberculosis infection of Bovine (cow) origin, while many others suffer disabling and deforming illnesses. Pasteurisation, properly performed, reduces the risk of tuberculosis and other milk-borne infections to the vanishing point."

Attention must also be drawn to a memorandum on Bovine Tuberculosis in Man issued by the Ministry of Health, which states :

" Pasteurisation carried out in suitable apparatus and under strict scientific control is capable of protecting the consumer from the danger of infection with the tubercle bacillus, and milk so treated appears to retain its valuable food properties practically unimpaired."

Lord Horder has further stated :

" Experience has shown that when pasteurisation (the heating of milk under conditions which ensure the destruction of harmful bacteria, yet leave the vitamins unimpaired) is generally practised, infection traceable to milk recedes almost to vanishing point."

Similar sentiments are expressed in the Report of the Medical Research Council issued by the Ministry of Health, in October, 1942, which deals with the increase in the number of cases of tuberculosis which have occurred under war conditions. This Report also lays stress upon the necessity for the compulsory pasteurisation of milk as a means of combating the increased incidence of this disease throughout the country.

Such statements are direct refutations of any argument that milk is not responsible for the conveyance of tuberculosis. As Wilson has so correctly pointed out, if the facts regarding the transmission of bovine tuberculosis by means of milk are doubted, the whole germ theory of disease no longer holds good and the whole hygienic code based upon this theory must be scrapped.

(2) Pasteurisation has not in all cases killed any tubercle bacilli present in milk, as such organisms have, in certain cases, been discovered in pasteurised milk.

Persons making such statements would do well to remember that there are two ways of pasteurising milk—efficiently and inefficiently. If the process is carried out by methods not in accordance with recognised practice, that is, inefficiently, it is quite possible that all tubercle bacilli which may be present will not be destroyed by the process. Particularly is this so if the temperature is not sufficiently high, or the holding period of insufficient length. *Efficient* pasteurisation has been definitely proved to be a certain means of destroying any tubercle bacilli present in milk.

The table below shows that under the present Order and Regulations, the requirements as to time and temperature with either system afford the consumer an adequate margin of safety if strictly adhered to.

TABLE 16.

Organisms.	Destruction Time at 140° F.
Tubercle bacilli	20 minutes.
Diphtheria ,,	1 minute.
Typhoid ,,	2 minutes.
Dysentery ,,	10 minutes.
Brucella abortus	10 to 15 minutes.
Streptococcus pyogenes	Under 30 minutes.

(3) Outbreaks of disease have been traced to the consumption of pasteurised milk.

In all cases of infectious disease traced to pasteurised milk, it has been found, except in the case of milk inefficiently treated or handled, that such infectious disease has been due in every case to the human element handling milk. This human element may be responsible for many mishaps, therefore it is not always possible to guard against such happenings, although all reputable firms expect a clean bill of health from their employees. In several outbreaks of milk-borne disease, it is recorded that pasteurisation has been the means of stopping further infection, and this fact is, or should be, sufficient proof of efficiency of treatment in the protection of the public from infectious disease. The increased use of pasteurisation, both in this country and in America, has been followed by a considerable reduction in the incidence of non-pulmonary tuberculosis and by a diminution in the number of epidemics of milk-borne disease.

(4) Pasteurisation destroys the nutritive properties of milk while the destruction of lactic acid organisms conceals the fact that milk is deteriorating.

Regarding the destruction of those properties which make milk such a valuable food, no better reply may be given to such a statement than to quote Dr. J. M. Hamill, who has stated in his report to the Minister of Health : " Notes on the Pasteurisation of Milk," *Reports on Public Health and Medical Subjects*, No. 17, 1923 :

" The nutritive qualities of milk in conformity with its physical and chemical characters do not appear to undergo any appreciable change as a result of pasteurisation, except in respect of anti-scorbutic properties. It has already been mentioned that the anti-scorbutic vitamin in milk is impaired by pasteurisation. Fortunately, however, this defect in pasteurised milk is readily corrected by the administration of an anti-scorbutic, such as orange juice."

He also adds that the important positive advantages accruing from pasteurisation may be regarded as outweighing any possible slight depreciation in nutritive value. Dr. H. C. Corry Mann, in an address before the World Dairy Congress in 1928, speaking of his experiments, said :

" For over three years past, low-temperature pasteurised milk has been given to children under the age of two years without a ration of orange juice. There has been no incidence of scurvy. No increase in growth rate and no improvement in nutrition has ever been noted from the addition of orange juice to a diet of milk pasteurised by this method."

Emphasising the startling improvement in weight and height of growing boys fed with a sufficient daily diet plus one pint of milk daily, Dr. Mann further stated :

"The improvement was most successful when fresh cow's milk recently *pasteurised*, from a clean and reliable source, formed the additional item of food, and such improvement both in weight and height increments was not a temporary phase, but was maintained over a period of one, two and three years."

During the last few years, a large number of scientifically-controlled experiments have been carried out to ascertain any existing nutritional differences between raw and pasteurised milk. Calves fed on the pasteurised product have been found to gain slightly in weight per day when compared with those fed on raw milk, while, in addition, there was freedom from infection by tubercle bacilli. Experiments carried out by the Milk Nutrition Committee over a twelve months' period, in which many thousands of school children were fed, have demonstrated that so far as nutrition is concerned there are no constant differences between the growth rates of children receiving milk, whether raw or pasteurised. The chief Medical Officer of the Ministry of Health in his Annual Report for 1937, referring to these experiments, stated :

> "the enquiry provides important information . . . which reinforces the steadily accumulating evidence that pasteurisation has no significant effect on the nutritional value of milk."

Such testimonies as those are important, particularly as they were made after a period of prolonged and careful investigation. It must be emphatically stated that scientists and research workers have discovered that, if the process is correctly applied, milk remains milk and retains practically its entire nutritive value, and any losses resulting from processing cannot be differentiated by actual feeding experiments.

The question of souring of milk is easily disposed of. In the first place, this liquid is generally consumed on the same day on which it is delivered, it being an uncommon practice to keep milk for more than twenty-four hours. It has therefore no time to become sour. Further, in efficiently pasteurised milk sufficient lactic-acid organisms survive the heating process to ensure that the product will become sour before putrefaction commences.

(5) The compulsory pasteurisation of all raw milk supplies would cause the extinction of a large number of small dairymen from business.

This in itself is no reason why pasteurisation should not be rendered compulsory. The small distributor, if unable to supply his customers with a clean safe milk, is better out of business. The working of the Milk and Dairies Order, 1926, even where strictly applied, has not been the cause of any farmers ceasing milk production. In the same way, any Order enforcing compulsory pasteurisation would have little effect *per se* on the small dairyman. Universal, compulsory pasteurisation will not be practicable for some time, but it would result in the production of cleaner milk generally, as it would have to travel to urban areas for treatment. The day of the small dairyman is passing, and the anomaly of several such persons, each delivering a few gallons of milk within the same area is rapidly becoming a thing of the past. This will result in the combination of several small distributors with consequent benefit to the consumer. Such persons are able, if they wish, to procure sufficient milk for their needs, already pasteurised, from one of the large processing companies, and do not require to provide expensive plant for the purpose. Compulsory pasteurisation will only come at the instigation of the authorities concerned, and when it does, as it certainly will, both public and milk trade may rest assured that there are good and sufficient reasons for such compulsion.

The recent White Paper envisages the provision of independent pasteurising plant by local authorities to handle milk of small producers, and where it proves impossible for suitable arrangements to be made by the trade itself, such bodies are to be allowed to safeguard the interests of small producer-retailers and dairymen by arranging suitable means of treating their milk.

(6) The agricultural community quite frequently state that the compulsory pasteurisation of milk would result in the standard of raw milk production being considerably lowered.

Apart from the fact that no general standard for raw milk exists and that much milk now produced is comparatively poor from a hygienic point of view, it must be borne in mind that the production of clean, raw milk can be most adequately assured by requiring a pre-pasteurisation standard of cleanliness for all raw milks to be subsequently processed. Recent bacteriological studies have shown that clean milk is quite as important to pasteurisation as it is for distribution in its raw state. Carelessly produced milk cannot be efficiently pasteurised, it having been demonstrated on innumerable occasions that many organisms found on dirty dairy utensils possess special properties for resisting destruction by temperatures which kill ordinary forms of non-sporing bacterial life. Steam sterilisation for all milk utensils at the point of production will reduce or even practically eliminate the number of bacteria surviving pasteurisation. The sterilisation of milking machines is particularly necessary as, if neglected, millions of heat-resistant organisms may be added to milk.

In spite of their arguments, opponents of pasteurisation have not yet brought forward any alternative process which will guarantee the wholesomeness of milk. One feature of these statements is the fact that their authors appear to confuse the pasteurisation process with that of sterilisation, as they often mention " boiling " of milk. This is quite often the case amongst members of the agricultural community. It is indeed probable that many of them do not actually understand what efficient pasteurisation really means. A definition of the process will be found on page 260.

All food-stuffs, including milk, should be consumed in as fresh a condition as possible, but, owing to circumstances which often exist in large urban areas, it is essential that the keeping quality of milk should be so improved without altering its food value in order that it can be sold to the public in a sweet condition. If this were not done, a large proportion of the population would be compelled to go without this food, and farmers would be unable to sell all the milk they produce. The ideal would be for all milk to be produced from *perfectly healthy* cows under hygienic conditions, and for it to be consumed within the shortest possible interval after production. There is great difficulty, however, in freeing herds from tuberculosis and of keeping them free from the disease, to which must be added the expense attached to such eradication. Milk of this high quality is, by reason of its excellence, limited in quantity and, owing to its higher cost, cannot generally be afforded by the ordinary consumer. The bulk of the country's milk supply does not approach this high standard, and, as much of it has to be transported for long distances, it is essential that the product should be treated in some form, not only to render it safe but also to keep it sweet until delivery. It should be noted that the Committee on Animal Diseases of the Economic Advisory Council recommended that the introduction of some measure of compulsory pasteurisation should be no longer deferred. That was some years ago, but no steps were taken until 1944, when the Minister of Food was empowered by Defence Regulation 55G to order that milk in specified areas should either be " Tuberculin Tested," " Accredited " from a single herd or " Pasteurised."

Two final quotations state the position clearly from the public health, the most vital, aspect. Sir George Newman,[1] in presenting the aforementioned report of Dr. J. M. Hamill on the pasteurisation of milk, makes the following comments :

> " It is generally recognised that milk obtained from perfectly healthy cows, under the cleanest conditions, cooled immediately and distributed with the least possible handling and delay, is the best that can be procured. The difficulty in existing circumstances, however, of securing such ideal conditions for milk production inevitably restricts its supply. In a highly urbanised country such

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[1] " Notes on the Pasteurisation of Milk "—*Reports on Public Health and Medical Subjects*, No. 17, 1923.

as England, transport and distribution complicate the problem of a satisfactory milk supply and, in order that an adequate, safe, and cheap supply of milk should be readily available for everyone, it is necessary to have recourse to pasteurisation, which has already proved so valuable in the milk supply for cities in the United States of America. But pasteurisation must be properly done if milk is to be rendered safe, its keeping qualities improved, and its nutritive properties not affected."

The issue of "*The Medical Officer*" dated June 15th, 1935, contains the further illuminating paragraph :

> "Undoubtedly the right way to protect man from milk-spread tuberculosis is to free dairy herds from tuberculosis. This can be done, and to a limited extent is a feasible proposition. The Channel Islands have been freed from bovine tuberculosis ; many selected herds have been freed ; but to free the whole of the cattle of this country from tubercle is not feasible—or rather it is not feasible to try to do it at once. We must accept this, so we must look about for an alternative. This we have in pasteurisation, which is feasible. It is not ideal—nobody ever submitted that it was ideal—but it is feasible and can be reliable. But whilst we are using this palliative, we should get along with the main business of stamping out tuberculosis from milch herds. So pasteurisation must not be made an excuse for shirking the correct but more laborious and costly ideal."

STASSANISATION

This is a comparatively new, high-temperature, short-time method ot treating milk by heat, and takes its name from its inventor, Dr. Stassano, an Italian member of the Pasteur Institute in Paris. Stassanisation, although actually a modification of the "Flash" method of treatment, is entirely different from the high-temperature, short-time method previously described, and at present has not been recognised as complying with the present Regulations dealing with this method of processing. The first extended trial of stassanisation was carried out at the Danish State Experimental Farm, but Dr. Stassano has also carried out tests with the milk supply of Strasbourg and elsewhere.

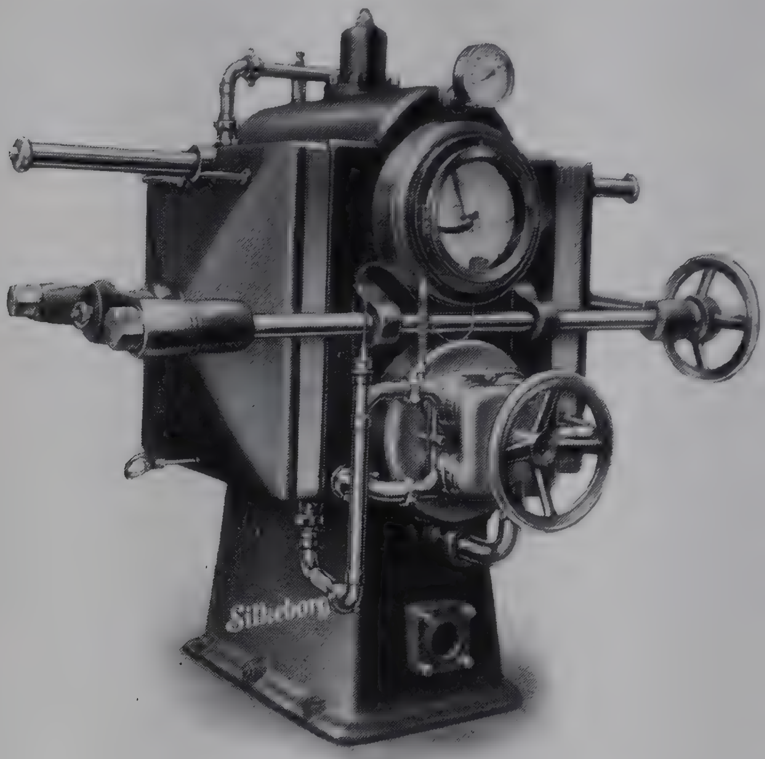
The process takes place in a completely closed tube in which milk is distributed in thin layers without access to air, each layer being about one-twenty fifth of an inch in thickness. The milk is rapidly heated on both sides under slight pressure and in such a way that it is unable to lose its carbonic acid content. The temperature attained is 165° F., milk being in contact with the heating surface for 15 to 16 seconds. This rapid heating is followed by speedy cooling to a temperature of approximately 58° F. The heating agent is hot water at a temperature of 166·8° F., i.e. slightly above stassanising temperature.

Two types of plant are employed. The older type consisted of the following individual items :

(1) Milk Filter.
  This is a closed pressureless filter, milk flowing through by gravitation.
(2) Constant-flow Milk Pump.
  This is a slow-working apparatus which exerts no mechanical influence upon milk.
(3) Heat-exchanger and Cooler.
  Milk is led in a regular spiral course without acute angles.
(4) Stassaniser.
(5) Water Heater.
(6) Hot-water Pump.
(7) Cold-water Pump.
(8) Brine Pump.

The stassaniser consists of three drums, each possessing four double tubes. An opening of approximately 1 to 1·25 millimetres is provided between the inner and outer tubes through which milk flows. The total length of tubing is approximately 22 yards, this length being fairly equally distributed between regenerator, stassaniser, and cooler. The tubes are continuous and are connected in pairs. Each set of double tubes is joined by means of end-pieces in the drums. The connection between the individual pipes in the ends of the drums is established through a fixed cover, which is tightened by means of a hand-operated wheel. The joints are milk- and water-tight, and any leakage, which can only be due to insufficient tightening of the end-pieces, is quickly detectable. Two pumps are provided, one of which is used for circulating hot water and the other for circulating milk. The water temperature is maintained by admission of steam. Thermometers are fixed at inlet and outlet of each drum, so that adequate temperature control is provided. If desired, recording thermometers may be fitted. The pump can be adjusted to vary the milk pressure as desired and is designed to ensure that air is never pumped into the liquid.

Milk first passes through a filter, from which it flows by gravity to a regenerator where it meets the hot liquid from the stassaniser. Heat is exchanged between hot and cold milk, the temperature of the heated liquid being 122° F. on leaving the regenerator. It is next pumped through the stassaniser, being further heated to 165° F. and is maintained at this temperature for fifteen seconds during its progress. It then returns to the regenerator, where it yields a portion of its heat to incoming cold milk, the temperature being reduced to 86° F. by this means. The milk finally passes to the cooling section, where it is cooled by means of water or other cooling agent to the desired temperature. The time taken to pass through the plant from receiving tank to outlet is two and a half minutes. The apparatus is constructed to treat various capacities, from 66 to 1,760 gallons of milk per hour.



By courtesy of Hiron & Rempler Ltd.

FIG. 188. "Silkeborg" Stassaniser.

The modern stassaniser, shown in Fig. 188, is much more compact, the principles involved in treatment being similar to those mentioned above. This is a combined apparatus consisting of stassaniser, plate heat-exchanger, and cooler, the plate sections serving as storage for hot circulating water. One or more stassanising drums can be provided within a common framework, each drum possessing a capacity of 440 gallons of milk per hour. Cleansing of the tubes, which are constructed of stainless steel, is simplified, each tube being just over one yard in length. Quite lengthy tubes were provided in the original apparatus, but experiments have shown that the provision of shorter components in no way affects the quality or safety of the final product.

It is claimed that cleansing operations are quickly accomplished. These are commenced by pumping clean cold water through the plant until this water, on emerging from the cooling section, is free from any trace of milk. A weak soda solution or other detergent is then circulated several times, through the pipes followed by boiling water. Steam is finally blown through the pipes for sterilisation purposes. When the end-pieces are opened, the inner tubes can be extracted and cleansed by means of the special brush provided.

This plant is stated to be more economical in the use of steam than the normal low-temperature holding apparatus and, from a distributor's point of view, the following additional economic advantages are claimed :

(1) Minimum working expenses.
(2) No losses through evaporation.
(3) No losses through spoiled returns (milk of decreased value).

From a public health standpoint, the results of experiments carried out at the Danish State Experimental Farm and by other experimental bodies on the Continent may be summarised as follows :

(1) No difference could be ascertained in odour, flavour, or appearance of milk before and after treatment.

(2) Cream-line was not seriously affected, stassanised milk exhibiting a very satisfactory cream-line (in one instance, however, reported from Kiel, it was stated that cream-line was considerably reduced).

(3) Milk kept fresh for forty-eight hours and at the end of that period did not possess a disagreeable taste.

(4) The curdling ability of milk by the addition of rennet was not influenced, and digestibility of the proteins was retained.

(5) Vitamins A, B, and C were not influenced by process.

(6) Only 8 per cent. soluble protein was altered during the processing.

(7) Practically all non-pathogenic organisms were destroyed.

(8) The treatment destroyed all coliform bacilli present, together with any pathogenic organisms contained in milk.

(9) Very little slime or milkstone was present.

(10) The plant was found to be extremely economical in the use of steam power, water and brine.

As in all other methods of treating milk by heat, strict temperature control is essential.

The first stassanising plant erected in this country was constructed at a dairy in Stockport, where apparently the method gave complete satisfaction in everyday use. One experimental plant has been installed in a London dairy, but no results of the experiments carried out have yet been made public. In view of the small number of experiments undertaken by responsible authorities in this country, an open mind should be kept on the subject until sufficient evidence is available to decide whether this method of treating milk is likely to yield better results than the present low-temperature process. Given adequate, efficient temperature controls and fitted with a suitable flow-diversion valve, it would appear that this plant might be rendered suitable for processing milk in accordance with the terms of the Regulations of 1941.

THE ELECTRO-PURE PROCESS

This short-time method which employs electricity as the heating agent is fairly popular in America. Milk is heated by means of an electric current which passes between carbon electrodes in a small specially constructed chamber. This chamber, which has a cross-section of approximately 2 inches, possesses two walls composed of flat carbon electrodes, separated by intervening walls of plate glass. The current passes through the milk as it flows upwards between the electrodes, the electrical resistance of the liquid resulting in the liberation of heat, while the temperature attained is regulated by the amount of current supplied. Cold milk flows from a storage tank into a balance tank in which the milk level is controlled by means of a float. It is then pumped through a heat-exchanger, where the temperature is raised to 120° F. by means of outgoing milk. This pre-heated milk then passes through the electrical heating chamber, its final temperature being governed by an automatic device. After treatment the milk passes through a flow-diversion valve, and any liquid which has not attained the desired temperature of 160° F., this being the temperature employed in processing, is re-directed into the balance tank for re-circulation through the apparatus. If temperature is correct, the milk passes through the heat-exchanger, where it is cooled and finally flows to the bottling machine. This is another type of apparatus which, provided adjustments were made as regards time and temperature, would appear to be suitable for treatment of milk by the short-time process. Holmquist has reported on tests carried out by him on milk treated by this method, and has stated that a temperature of 153·9° F. maintained for 12·4 seconds rendered tubercle-infected milk non-pathogenic to guinea-pigs.

STERILISATION

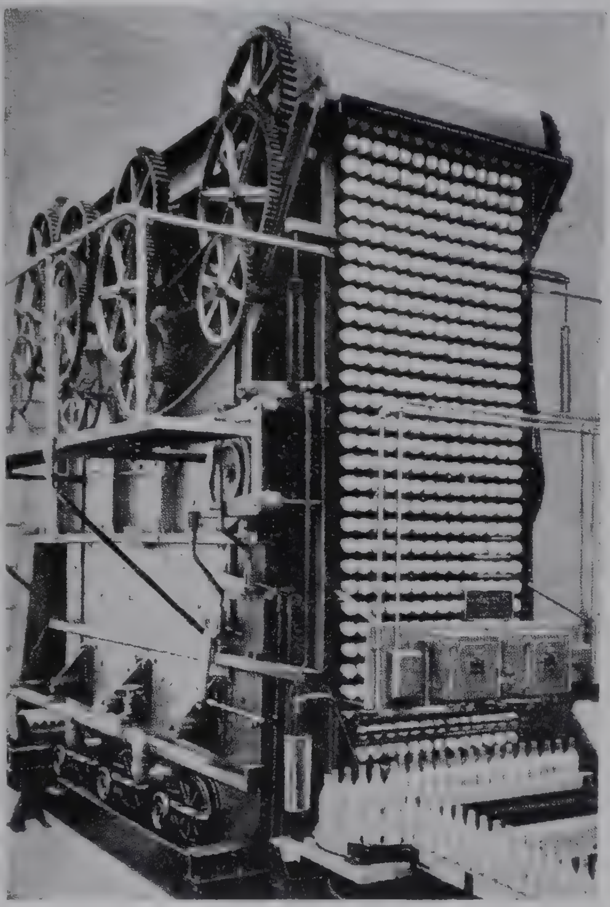
Confusion still appears to exist in the minds of many persons regarding the difference between sterilised and pasteurised milk. It should therefore be emphasied that, in this connection, the word " sterilised " is used to denote milk which has been heated to a temperature of at least 212° F.

Heating milk to the high temperatures which are attained in the process of sterilisation has a detrimental effect upon final nutritive value, while the resulting product possesses a distinct flavour which, however, appears to be enjoyed by many consumers. Introduced into this country in 1896 sterilised milk is now sold in large and increasing quantities, particularly in urban areas, where it is commonly retailed from general stores in the poorer localities. This increased sale is particularly noticeable in the London area and in the Midlands, and, as a result, sales of pasteurised milk have lost a certain amount of ground. On account of its keeping qualities and the even distribution of its cream, sterilised milk appeals to the housewife, who considers that milk puddings and other cooked milk dishes are considerably improved by its use. The consuming public are regrettably ignorant of the biological properties of milk, and do not recognise that immunity from souring, which is the chief property of sterilised milk, has only been gained at the expense of decreased food value and this loss of certain health-giving properties normally possessed by milk is by no means unimportant. Bone- and tissue-building salts are rendered less easy of assimilation, vitamins are destroyed, and lactic-acid organisms are entirely eliminated. In spite of these facts, the demand for this type of milk has forced large distributing companies to produce such an article. It must be remembered that, in spite of its loss of nutritive value, it is a "safe" milk from the public health viewpoint.

During sterilisation, the milk is first filtered or clarified to remove dirt and pus-cells, and is then pre-heated to render it less viscous and to assist its passage through the homogeniser. Homogenisation, which is carried out at a pressure of between 2,000 and 2,500 lb. per square inch, and at a temperature of 160° F., breaks up the fat globules in milk. Without this treatment, cream would appear on the surface of milk after sterilisation as a yellow oily fat. Following homogenisation, the hot milk is filled into sterilised hot bottles, which are of a special narrow-necked type. The actual sterilisation is usually carried out in one of two ways, as follows :

(1) Treatment may take place in steam-jacketed tanks, bottles being immersed in water to the necks. This water is maintained at a temperature of 212° F., and bottles remain submerged in the heating medium for one hour. In some cases the containers are stoppered after expansion has taken place and are then subjected to steam pressure until the temperature reaches 222° to 226° F. When this process is completed, the bottles are removed and gradually cooled in water when they are then ready for delivery.

(2) Bottles, already crated, may be placed in a steam chest with the stoppers loose. A thermometer is fitted which enables the temperature of one bottle to be seen from outside the chest. Steam is admitted and the milk temperature is raised to 212° F. This is maintained for some twenty-five minutes, when steam is shut off, the bottles being stoppered while the chest is still hot. They are then cooled as previously described.



By courtesy of R. Webster, Ltd.

FIG. 189. Milk Sterilising Plant.

Various types of plant, automatic in action and capable of dealing with 300 to 1,000 gallons of milk per hour may be obtained. Automatic loaders are provided, usually arranged so that obstructions due to fallen or broken bottles, halt the forward movement of bottles until matters have been rectified, while processing is carried on undisturbed. Carriers are provided into which bottles are loaded, and these travel upwards through a warm, hooded section of the apparatus into the water tank. This tank, which is usually duplicated at the opposite end of the apparatus, acts as a water seal, maintaining steam pressure in the central closed holding tank, where bottles remain for thirty minutes. They then pass through a second hot water seal into a cooling tank, meeting a gradually cooling stream of water as they move forwards. Air cooling is employed at this point, and finally the bottles, totally submerged, travel through a tank of cold water maintained in an overflowing condition in the base of the apparatus. Feed and discharge points can usually be placed at any convenient point. Fig. 189 as at a modern type of plant.

Bottles of sterilised milk are sometimes cooled by means of a cooling tunnel, gradually reducing temperatures being provided. Bottles in their crates travel through this tunnel and are cooled by a combination of atomised air and water. The final milk temperature is within 10° of the mains water employed. No refrigeration is required as milk, having been sterilised, is, or should be, practically free from micro-organisms. While cooling is in progress, the external surfaces of bottles are thoroughly washed while they may be dried, if desired, by means of a thermostatically-controlled air draught. If milk is steamed under pressure, the final product should be sterile, but some methods of processing permit spores of thermoduric organisms to remain unhurt, causing the production of acid and gas which eventually renders milk unmarketable. On this account, clean, raw milk is just as essential for treatment in this way as it is for other methods of processing. The bacterial content of sterilised milk at the time it leaves the plant should at no time exceed 10 organisms per millilitre.

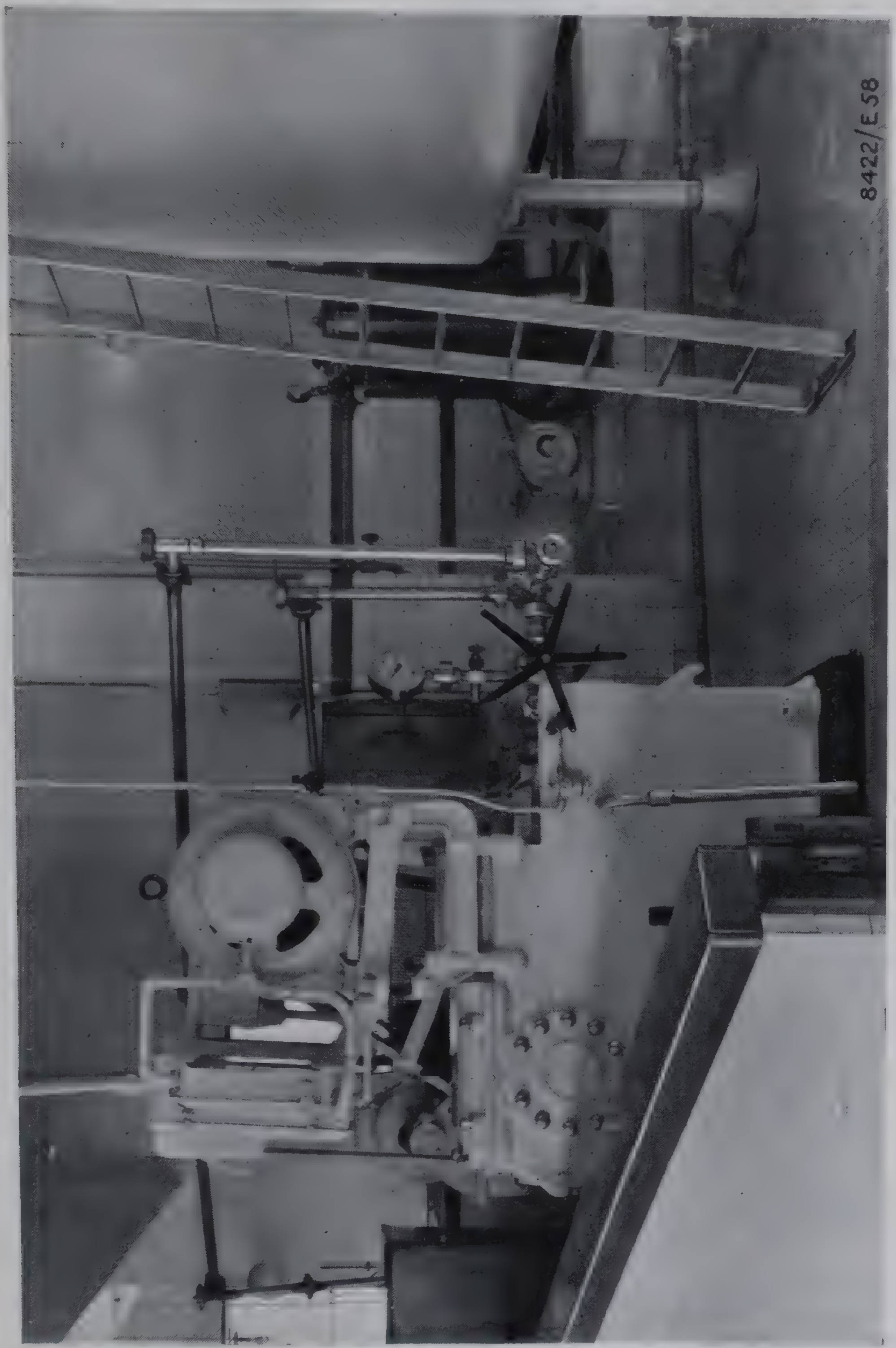
It is not practicable for a small distributor to sterilise milk efficiently unless he can obtain his supplies already clarified and homogenised. The apparatus necessary for subjecting milk to such treatment is expensive and cannot be profitably installed in small dairies. Sterilised milk has no cream-line, and is generally retailed at a slightly higher price than other varieties of milk. This may retard sales in certain instances.

HOMOGENISATION

"Cream-line" pasteurised milk can never be re-mixed in its proper proportions in order that the lower levels of milk in any bottle will always contain their normal quota of cream. The claim of the housewife that homogenised milk has a rich creamy taste throughout, and that it improves the flavour of tea and other beverages, has been the means of improving the sale of milk treated in this manner, a 25 per cent. increase occurring in many instances. Pasteurised milk usually is judged, quite falsely, on the cream exhibited on the surface of the milk, and one advantage of homogenisation is that the absence of any cream-line renders such false judgment impossible. When the public realises that lack of cream-line does not necessarily mean lack of cream, the sales of homogenised pasteurised milk should speedily increase. There has been, and in some plants there still is, one serious drawback to the treatment of milk by homogenisation. This is a periodic tainting of the product with an oily or metallic flavour which appears to be introduced during processing. The large distributors have carried out many experiments to eliminate this defect, and it has now been found possible to prevent these flavours by the employment of stainless metal for all parts in contact with milk.

Homogenisation was first introduced from France by A. Gaulin, in 1902, and this process has now become indispensable to both dairy industry and other food trades. Sterilised milk has been homogenised from its inception for reasons already set out on page 343, but the application of the process to milk prior to pasteurisation followed at a much later date.

During the homogenisation process, the fat globules contained in the milk are subjected to an emulsifying process and are reduced to such fine proportions that the distribution of fat throughout the liquid is completely uniform. This treatment gives a greater apparent creaminess to milk owing to the greater surface of fat introduced to the palate. When milk has been homogenised, cream globules will not return to their normal size for a considerable period, although the process causes no diminution of bacterial content, no destruction of pathogenic organisms, nor any change in the chemical composition of the milk. In other words, it is an entirely commercial process. Cold milk can be homogenised, but to obtain satisfactory results it must first be heated to reduce viscosity.

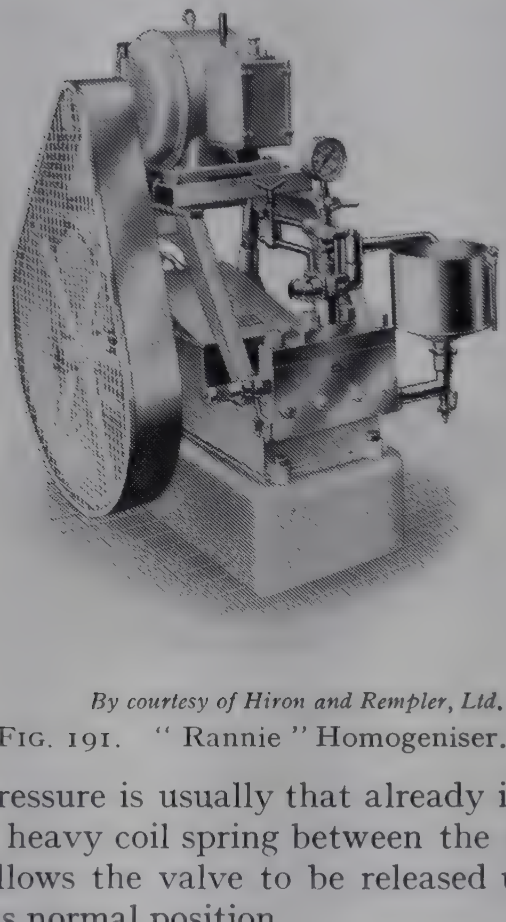


By courtesy of the Brush Electrical Engineering Co., Ltd.

FIG. 190. "Brush" Homogeniser.
(Capacity 500 gallons per hour.)

One point regarding this type of milk must be noted. If it is allowed to stand for any length of time, a ring of sediment frequently forms at the base of the container. This appears to be similar to very fine dirt or grit mixed with some of the milk solids. Slides prepared by the Breed method (see page 364) show that this slime consists largely of leucocytes and epithelial cells. In milk which has not been homogenised, these cells are, to a large extent, carried to the surface with the cream, but in the homogenised product, lack of fat globules as such allows these cells to settle at the base of the bottle as sediment. A similar phenomenon has been noticed in connection with sterilised milk. There is no correlation between homogenisation pressure and formation of sediment, this latter being most pronounced when milk has been standing for twenty-four hours. The quantity noticeable always appears to be the same, irrespective of pressure employed, and, in some instances, milk is filtered to remove the sediment after treatment is completed.

Milk is usually homogenised following a primary heating, before it is pasteurised, receiving a further heating before passing to the holder. The temperature of milk is usually 140° F., the heat generated during processing raising the milk temperature to that required for final treatment. Heated milk is forced through a small valve against a hard surface, and is subjected to a pressure of between 2,000 and 2,500 lb. per square inch. The normal fat globules in milk are broken up into minute particles, due to their passage from a region of high pressure into a low-pressure atmosphere, plus the action of the hard surface against which they are required to impinge. The natural suction of the machine draws milk inwards, when it passes to cylinders whose inlet valves close on the pressure stroke. The apertures through which the liquid is forced are extremely minute, having a diameter of $\frac{1}{10,000}$ inch. The outlet valve can be adjusted to supply any pressure, but, during homogenisation, this pressure is usually that already indicated. The valve is spring-loaded with a heavy coil spring between the adjusting screw and the valve disc. This allows the valve to be released under excessive pressure and to return to its normal position.



By courtesy of Hiron and Rempler, Ltd.

FIG. 191. "Rannie" Homogeniser.

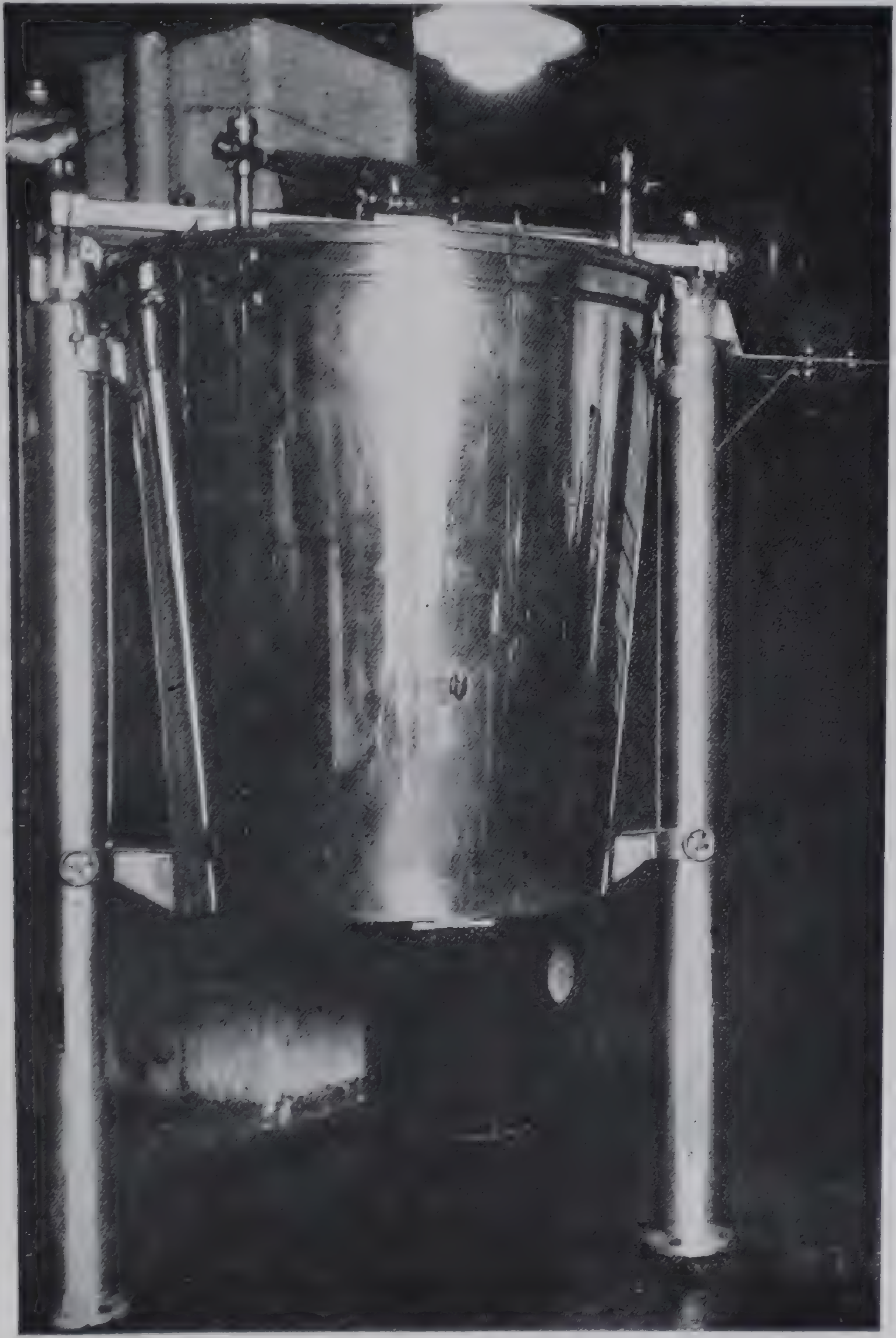
All parts of the apparatus coming into contact with milk should be constructed of acid-resistant, stainless steel, while piping should afford easy accessibility for cleansing purposes. Homogenisers are heavily constructed to withstand the high pressures involved and can be obtained to treat any quantity of milk up to 1,250 gallons per hour. As these plants are expected to carry out strenuous work in a successful manner, they should receive careful attention if they are to possess a long, active, trouble-free life. Figs. 190 and 191 illustrate two modern types of homogenisers.

Homogenisers should be properly cleansed and sterilised immediately processing is completed, cold water being pumped through the apparatus under pressure, until clear water is discharged. Any removable parts should be washed and scrubbed separately. This treatment should be followed by hot water rinsing with final sterilisation by boiling water or steam. The apparatus should then be reassembled and hot water pumped through under pressure. A further hot water wash should be given with sterilisation as the final treatment.

Homogenised milk is of particular use in hospitals and other institutions where the practice of "skimming" the supply after delivery is suspect. Its greatest recommendation is probably its digestibility. In many cases, infants cannot retain milk in their stomachs and homogenised milk will be found to be of the greatest value, as it is easily assimilated.

IRRADIATED MILK

This method of treating either raw or pasteurised milk, although still in its infancy, has already been practised commercially in this country with

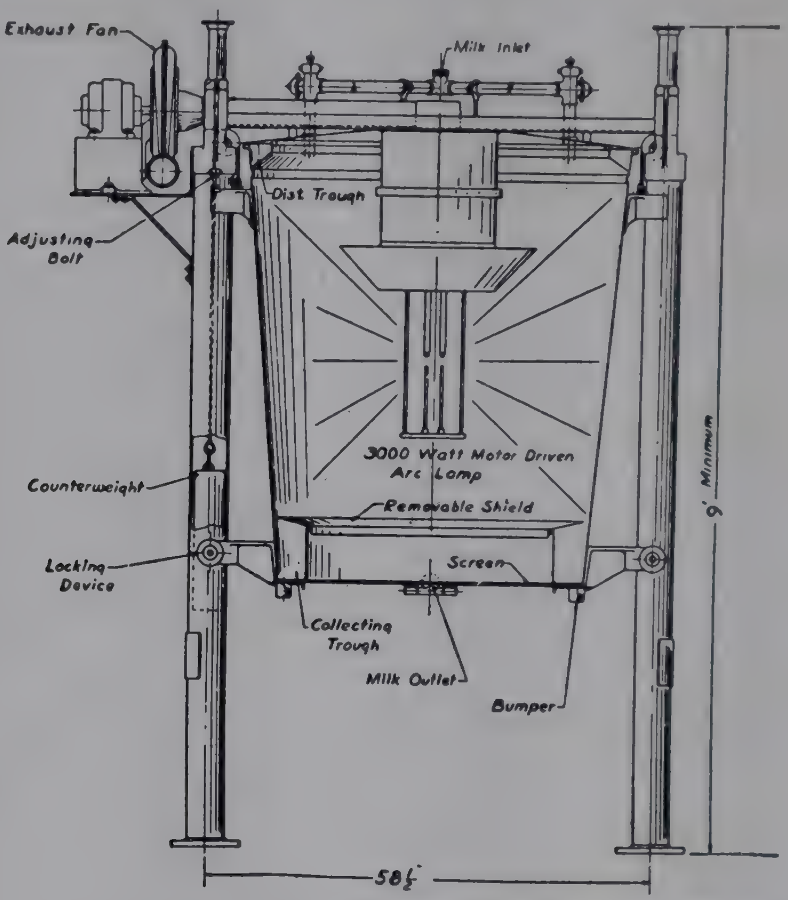


By courtesy of the Creamery Package Co.

FIG. 192. C.P. Milk Irradiator.

success. The process consists of the very short exposure of a thin film of milk to the rays of a mercury-vapour lamp or other reliable source of ultra-violet radiation. The object of the process is primarily to improve the food value of milk without diminishing the nutritive values already present. Steenbock and other investigators have demonstrated that milk develops anti-rachitic properties when exposed to ultra-violet irradiation, by increasing the vitamin D content. When consumed in the customary quantities, such milk will thus give adequate protection against rickets in infants or tooth decay in adults.

Rickets is a disease commonly present among children of the poorer populations of our large cities and towns. Although its causes have not been definitely ascertained, it is known to be a deficiency disease, possibly due to faulty feeding or faulty assimilation, lack of sunlight or fresh air or a combination of these faults. Attacks by this disease are insidious and often overlooked. Persons of any age may be attacked, especially after long illnesses, but the greater proportion of children contract the disease during their second year of life. The disease affects the whole body and its various functions, changes in bone structure being of the greatest importance.



By courtesy of the Creamery Package Co.

FIG. 193. C.P. Milk Irradiator (Section).

The part played by sunlight is closely allied to the question of food deficiencies. This disease is unknown in tropical regions, while in the earth's temperate zones, cases are more prevalent in winter than in summer. The position was clarified when it was found possible to render foodstuffs anti-rachitic by exposing them to the action of ultra-violet rays. A substance named *ergosterol* was found to be present in fats, and this substance, by irradiation, can be converted into vitamin D. Ergosterol is present in fat underlying the skin of both humans and animals and, by the action of sunlight, is converted into vitamin D and passes into the animals' milk.

Once it was established that irradiation was of assistance in improving the food value of an article, it became necessary to discover how the process should be applied. Dr. G. C. Supplee, of the Dry Milk Company of America, has carried out much pioneer work regarding direct irradiation of milk during the last ten years and has demonstrated that a measurable vitamin-D potency can be generated in milk in proportion to energy input. Two other steps were necessary following this discovery. The most suitable conditions for irradiation had to be found and proof was necessary that this form of vitamin D was successful in protecting human beings from rickets.

Supplee proved that a thin film of milk which received a short exposure to ultra-violet rays acquired plenty of vitamin D and, what was probably more important, processing did not produce any off-flavours in the liquid or damage existing vitamin-A content. Following these experiments, more reliable sources of ultra-violet light were found to be essential. The chief technical difficulty was that the older type of ultra-violet ray lamp failed to maintain a constant output of rays, and on this account, special high-efficiency lamps had to be devised. Concurrent with Supplee's experiments, Hess and Lewis showed that carbon-arc irradiated milk, produced under conditions prescribed by Supplee, gave complete protection against rickets in infants. In addition, it was found that irradiation of milk exerted a bactericidal action.

There are various systems in use, as follows :—

(1) *The Scholl Process.* In this process, oxygen is removed from air by admixture of carbon dioxide. Milk is irradiated in a water-cooled chamber, ultra-violet rays being provided by means of a quartz-mercury-vapour lamp which is fixed 3 inches from the milk film.

(2) *The Scheidt Process.* With this system, irradiation is arranged in a different manner, milk travelling upwards to the summit of a quartz tube. Ultra-violet rays are provided by a high-tension current passed through a pipe containing argon gas.

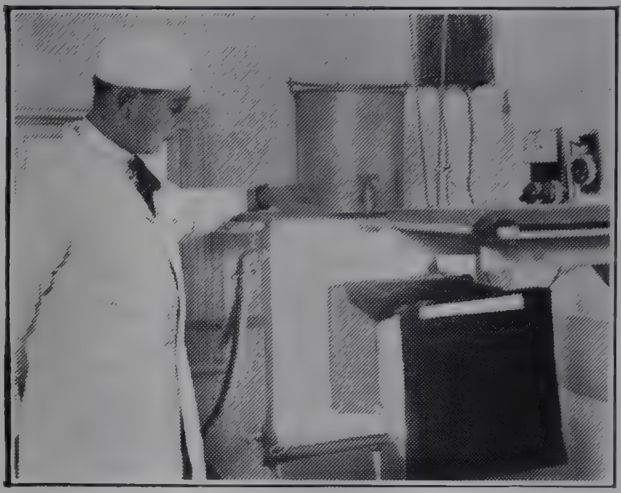
(3) *The C.P. Process.* This is an adaptation of the Steenbock process, the plant being sold under licence. The apparatus is cylindrical in form, milk being fed at a steady predetermined rate to a high-level distributor trough, from which it flows in a thin film, approximately one-third of a millimetre in thickness, over the inner surface of the cylinder. As the source of radiation, a carbon-arc lamp is centrally fixed, and as the cylinder provides uniform distribution of rays, all portions of milk receive equal exposure and are uniformly activated. The cylinder walls prevent any waste of light, render the use of shields or reflectors unnecessary and afford protection to the operators. The process provides maximum capacity in small space and is economical in the use of electric power and in labour costs. The carbon-arc lamp operates at 50 volts and 60 amperes across the arc. The following advantages are claimed :

(1) Radiation at full power is instantly available.
(2) Character and intensity of the radiation are constant.
(3) The carbon used is of the type best adapted for the purpose.
(4) Ultra-violet output of the lamp is ample for large scale production.

Milk is irradiated without any change in flavour or alteration to the existing vitamins.

Control of rate of flow is effected by the use of a positive fixed-capacity pump, while current to the lamp is regulated by an automatic control device which compensates for any changes in line voltage. The operation of the plant is indicated by a recording instrument which shows amperage consumed, operation of the supply pump, and duration of the run. The irradiating cylinder is mounted on brackets, which slide on supporting columns, and is balanced by means of counter-weights. The cylinder is constructed of stainless steel or of tinned copper, and is easily cleansed. Milk takes approximately five seconds to flow from top to bottom of the canister, where it is collected in a trough fixed immediately above the wire gauze at the base of the cylinder. The milk is exposed to the rays of the lamp for approximately five seconds, the safety margin being sufficient to prevent the production of any detrimental changes in milk. An extractor is provided to ventilate the interior of the canister.

(4) *The Cherry-Burrell System.* This method employs an apparatus in which a measured quantity of milk is allowed to flow downwards over a surface exposed to carefully controlled ultra-violet rays. A positive-metering pump distributes milk over the surface irradiated and is arranged so that the flow is stopped should the light be extinguished. If multiple lamps are employed and one lamp becomes defective, all remaining lamps are disconnected and the pump ceases to function. This prevents milk passing through the apparatus without being irradiated. The surface over which milk flows is designed to act also as a cooler so that milk may be cooled while irradiation is proceeding. Certain technical safeguards are provided. Any change in current voltage would result in over- or under-irradiation. A recording ammeter is therefore equipped with a second pen to indicate the current operating the motor of the measuring pump. By comparing the two records, it is possible to ascertain whether milk is flowing at the correct rate and that the arc lamp is burning with correct intensity. A recording ultra-violet ray meter is provided to show the degree of radiation efficiency, and the action of this instrument is comparable to that of a recording thermometer.



By courtesy of J. D. Hickman.

FIG. 194. Irradiation of Milk when passing over Cooler.

An ordinary *milk cooler* may be used for irradiation purposes, as shown in Fig. 194, but it is essential that only a very thin film of milk should pass in front of the rays in order to obtain full bactericidal action. The lamp should be properly shaded to concentrate the rays on the surface of milk being treated. As the short wavelengths most useful for this purpose are quickly absorbed, correct distance of the rays from milk is essential. Over-exposure of milk to the action of ultra-violet rays leads to the oxidation of the contained fat globules, this action being completed in eleven seconds.

Rooms in which irradiation apparatus is housed require special consideration. All air used for ventilation purposes should be drawn through dust filters. Preferably, such rooms should be air-conditioned, while fans should be provided to remove all products of combustion from the lamps together with any ozone which is produced. Eye protection for the operators is of extreme importance, as constant exposure to the rays will lead to painful irritation of the conjunctiva of the eyes. It is advisable to provide such rooms with special windows of darkened glass in order to permit the operator to observe processing without direct exposure to the lamp rays.

Milk may be treated either in its raw state or after pasteurisation, but it is always desirable to carry out treatment at as low a temperature as possible prior to processing. Milk treated in this way does not lose its potency by storage or by subsequent treatment.

The benefits of irradiation are twofold, and may be summarised as follows:

(1) *Cleanliness.* At one premises treating milk in this manner, the average bacterial count is consistently under 1,000 bacteria per millilitre. These satis-

factory results are assisted by hygienic methods of production. At this farm, all utensils are subjected to a short exposure of the mercury-vapour lamp after preliminary washing. As an instance of the effectiveness of this system, an experiment was carried out at the National Institute for Research in Dairying, Reading, with an artificially infected sample of milk. This was treated with irradiation, and the treatment effected a reduction of 98·5 per cent. in the total number of bacteria present. It should be remembered, however, that, where the number of bacteria in the milk is originally small, it is difficult to reduce this number still further.

(2) *Food Value.* As already mentioned, the vitamin-D content of milk is greatly increased. Experiments have also shown that vitamin D in irradiated milk is much more active than is the case in cod-liver oil. If the process is properly carried out, remaining food values of milk are not impaired in any way, cream-line is unaffected, and taste unaltered.

American and German investigators have established the fact that properly irradiated milk is of great value in the treatment of rickets, and this process seems to afford an ideal method of dealing with either raw or pasteurised milk. The process has not, up to the present, made any great advance in this country, but in America and Canada sales of irradiated milk are steadily rising. Increasing sales in this country are almost certain to follow within the next few years and, when this occurs, the cost of the product should be little more than that of ordinary milk.

CHAPTER X

LABORATORY AND OTHER CONTROL

STRESS has already been laid upon the necessity for suitable buildings, clean methods of production and distribution, and healthy herds, with a view to elimination of bacteria, pathogenic or otherwise, from milk. To ensure that the processes of milk production and distribution are carried out in a proper manner, some form of control is necessary from a public health point of view apart from any commercial control which may be exercised by other interested parties. This may be attained in one of three ways :

(1) Inspectorial visits and supervision.
(2) Laboratory control by sampling supplies.
(3) A combined method of inspectorial and laboratory control.

(1) Inspectorial Visits and Supervision

A multiplicity of legislation has been provided during the last few years, the object being to ensure that the production and distribution of milk are carried out in a suitably hygienic manner. Legal enactments, indefinite though they may be, lay down certain standards as to structural conditions in cowsheds and dairies, health of animals, cleansing of premises and utensils, and methods to be used in the distribution of milk. There can be little doubt that frequent visits and proper supervision are required to ensure that plant, methods and premises satisfy these legal requirements, and also to establish the fact that the health of animals is being checked by frequent clinical examinations. The idea behind such visits is that the procedure, if consistently carried out, would give a proximate indication of the quality of milk likely to be produced on the premises under review. Without any doubt, a great deal of good has been accomplished in this way and more is likely to accrue in future, but this procedure, if properly undertaken, is expensive in time and money, while, in addition it has distinct limitations. It should be borne in mind that no matter how good the premises or equipment may be, good results can only be obtained when the personnel use the equipment provided with judgment. Although this is readily granted, two questions immediately arise when considering inspectorial supervision from the public health viewpoint :

(*a*) Does frequent inspection, together with apparently satisfactory methods of production and compliance with a multiplicity of existing legislation, ensure the production of *safe* milk ?

(*b*) Are all animals yielding milk containing pathogenic bacteria readily detected by clinical examinations at frequent intervals ?

The answer to the former question is mainly in the negative. Producers of designated milks, working to a specific standard, can generally be trusted to maintain the necessary standard with reasonable regularity. For the bulk of milk producers of the country, however, there is no standard to which they are required to attain, and therefore they may do as they please within certain limits ; it should be mentioned that these are very wide limits and, indeed, in too many instances, they still produce milk without hindrance from any inspector. Granted the advent of the National Milk

Testing Scheme is likely to restrict their activities in this direction to some extent but it will no doubt be some years before every raw milk supply in the country is tested, graded and paid for according to its cleanliness. Even ideal inspection cannot ensure that certain methods, satisfactory though they may be, are carried out with unfailing regularity. It is well known that the provision of satisfactory buildings does not necessarily result in the production of clean milk, and no legislation in force at present or contemplated in the future, other than one fixing a definite bacteriological standard for *all* milk, can ensure the production of a clean product, owing to the constant difficulty of enforcement. The personal element must never be undervalued, and it is useless to threaten a producer with legal action if the cause of his transgression is ignorance of the principles which should be employed. In short, *supervision alone, even when combined with adequate educational measures, cannot provide a full and satisfactory measure of control,* although it must always have its place in any such system.

As regards (*b*), there can be no doubt that the most thorough clinical examination does not always discover diseased conditions in an animal, especially when such disease is in the incipient or latent stage and the proposals put forward for an annual veterinary inspection of dairy herds, even if this was sufficiently frequent, which it certainly is not, will not be likely to provide any considerable improvement in this respect. Particularly is this the case in animals affected with tuberculosis who may be yielding infected milk. As stated elsewhere, cattle can and do yield such milk without clinical signs of disease being present in the udder. Many instances have occurred where the presence of disease in the udder has only been discovered by biological, laboratory examination. This, in itself, proves the fallacy of relying entirely upon clinical examination of animals.

(2) Laboratory Control

The routine laboratory examination of milk supplies has many advocates, but the practice has not been devoid of criticism. In considering the question it should always be remembered that routine laboratory examinations, while indicating either the number of living bacteria in a given quantity of milk or otherwise demonstrating their presence, do not supply any indication as to the pathogenicity of such organisms. This inference is only permissible if more detailed examinations are carried out. Further, there was a most serious lack of standardised laboratory technique, with the result that critics of this system were quick to point out discrepancies, particularly in the plate count results obtained by different laboratories, even from samples obtained under identical conditions. It must be admitted that such criticisms contained a modicum of truth, but it is probable now that standardisation of testing methods employed has taken place, that the practice which existed in many quarters of regarding the results of laboratory examinations as of little practical value will lose its significance.

In spite of any disadvantages already outlined there can be no doubt that routine sampling of milk supplies can prove to be of considerable value wherever it is undertaken. Laboratory control is of use in any district, but it is, or would be if properly carried out, of most value in rural areas. As control is intended to minimise or even put an end to the production of unhygienic milk and prevent the transmission of disease, it is preferable to sample the product at its source, and, although samples taken during distribution are useful for many reasons, such sampling cannot possibly possess the same value as that undertaken at the point of production. A great deal of milk sold in the large centres of population is mixed or bulked milk produced from a variety of sources, and tracing back of any infection in such supplies to the original source is obviously a matter of the greatest difficulty. Sampling of milk in a routine manner at the point of production would no doubt involve some considerable expense, which would fall upon those authorities least able to bear it, i.e. the rural areas. Probably, therefore, some financial assistance would be required from the Government, or better still, from authorities of areas to which the milk is consigned, as such authorities are, or should be, vitally interested in the question. Such assistance, if provided, would be amply repaid. It might be objected that a great deal of testing is already carried out under the National Milk Testing Scheme. This is admitted, but it must be borne in mind that this scheme is purely commercial in conception and designed to prevent losses on account of premature souring. The scheme does not pretend to deal with the public health aspect of the milk supply. The process of routine sampling offers advantages which cannot, in any way, be obtained from inspectorial control. By sampling milk during delivery, proof of its quality in a particular district can be obtained without any visits to the farm or producing premises being necessary. It is generally accepted in such cases that a high bacterial content is due to inefficient sterilisation of utensils and improper handling of milk after production, while an excess *Bacillus coli* content is held to be the result of inefficient cleansing and grooming of the animals and also of dirty receptacles. Thus, proof of the hygienic quality of milk is definitely obtainable from laboratory examination. Such an examination may be utilised to supply the following information :

(*a*) A measure of the general bacterial and *Bacillus coli* content of the milk.
(*b*) Estimation of the presence or absence of definite pathogenic organisms.
(*c*) Evidential proof of any particular disease of the udder.

In all cases it is essential to interpret the results of laboratory examinations in the light of the conditions prevailing at the farm or dairy.

On these grounds alone, routine sampling of milk can establish a claim to be essential, while it possesses additional advantages to be detailed later. It is often argued that much time is necessary to carry out this work in an efficient manner. This is far from being the case, and, if staffs are not available for this work, they can hardly be sufficient to exercise inspectorial control, which occupies considerably more time and yields no indication as to the value of the article in question. Such sampling certainly involves increased expenditure and, unless the Councils concerned possess their own laboratory facilities, is not inexpensive. It should always be remembered, however, that routine examinations cost much less than do extra staffs involved in providing a sufficiency of inspectorial control. Especially is this the case when one considers the great number of premises throughout the country which require to be visited. It is a known fact that present-day inspection is often inadequate and that staffs provided to carry out the work are not only insufficient but often in receipt of inadequate travelling allowances, which fact prevents the proper exercise of control, especially in rural areas in which the bulk of producing premises are situated. It is therefore essential that some method should be adopted which will give an indication of the success or otherwise of the efforts of the producer and distributor, by providing definite proof as to the quality of the article marketed, and such methods should not be left to commercial interests but carried out by public health authorities.

Results obtained following the examination of a sample of milk yield information regarding the following factors:

(1) Care in methods of production.
(2) Whether milk is cooled or uncooled.
(3) Age of sample.
(4) Condition of the udder.

(1) Care in methods of production. It is obvious that, if milk is produced carelessly, it will almost certainly have a high bacterial content owing to the many sources of pollution to which it may be subject.

(2) Whether cooled or uncooled. Bacteria multiply with rapidity in milk at a temperature above 60° F. Conversely, the lower the temperature, the more slowly do organisms increase. High counts within a short time of production are very often due to lack of cooling.

(3) Age of sample. This is an exceedingly important factor and is closely linked with the question of cooling. The older the sample, the more bacteria are likely to be found.

(4) Condition of the udder. Very high bacterial counts in samples obtained from usually reliable sources, or from samples obtained immediately after production, may be due to some unperceived udder infection. An animal suffering from a mild attack of mastitis, even when clinical signs are absent, will excrete milk which contains an increased bacterial content.

In estimating the significance of results obtained from laboratory examinations, it is essential that the above factors should be considered together, the age of the sample and the temperature of milk when examined being carefully noted. Milk found to contain large numbers of organisms and which shows evidence of a high coliform content within four to five hours of milking must be considered definitely unsatisfactory.

However much care is taken by producer or retailer, however keenly the administration of the various legal enactments is carried on, or however constantly propaganda work affecting the milk supply is practised, such work cannot be accurately checked or its effects ascertained without laboratory control of milk supplies from both bacteriological and chemical standpoint. Medical officer of health, sanitary inspector, veterinary surgeon, producer, and retailer are all stones in the arch of milk control, but the *bacteriologist* remains the keystone.

Up to the present time, too little sampling has been carried out by the responsible authorities. Before any real success can be attained in the production of clean milk and its distribution, it is essential that more attention should be paid to this work, even if it entails reduction of inspectorial work at the point of production. The legal power to take samples is provided, and a number of authorities regularly take advantage of the facilities afforded. On the other hand, when the total number of local authorities in this country is considered, the percentage of those who carry out strict routine sampling is still very low, too many of them relying on other bodies to carry out what should be one of their primary public health duties. A large number of authorities sample milk spasmodically, but in very few instances is a definite plan of sampling attempted. It will be noticed that "routine" is mentioned many times in the foregoing paragraphs, and in this word lies the crux of the question. To be successful, sampling must be carried out at more than spasmodic intervals, as haphazard work can never hope to attain the desired result.

Various opinions are held as to what constitutes a sufficiency of samples. The writers are of the opinion that samples from each supply produced or sold in any district should be examined as regards bacterial and coliform content *at least once every three months*, i.e. four samples per annum with repeat samples as required. For the presence of tubercle bacilli each sample should be examined *at least once every six months*. Nothing short of this standard will suffice. As regards the presence of tubercular organisms, it is particularly important that milk should be examined every six months for the following reasons :

(*a*) All the cows in a herd may not be lactating when the first bi-annual sample is obtained, but those not in milk at that time would be dealt with by the second sample.

(*b*) Cows with tubercular-infected udders may only excrete tubercle bacilli periodically, and two samples at six-monthly periods minimise any likelihood of such affected animals being missed.

It may be mentioned here that many laboratories examine all milk samples submitted for the presence of *hæmolytic streptococci* and *Brucella abortus* although the results of such examinations are not as a rule communicated to the sender of the sample unless such information is demanded. In one case known to the writers, the milk sent to a certain laboratory is invariably examined for the presence of *Brucella abortus* with a view to discovering the incidence of contagious abortion among milking cattle of a particular district. A sampling scheme on these lines, if generally practised throughout the country, would do more to improve the standard of milk sold than has so far been attained by any existing legislation, provided, of course, that all unsatisfactory results were adequately followed up and advisory visits made.

Certain difficulties arise in rural districts with regard to the collection of samples, owing to the number of producers' premises to be visited. This can be overcome in either of two ways :

(*a*) Samples can be obtained with little loss of time at collecting depots or creameries from which milk is despatched.

(*b*) Samples can be taken only from supplies retailed in the areas in which they have been produced. Samples from milk consigned to towns could then be obtained at the point of distribution.

It is necessary, not only to sample milk produced in any particular area but also to sample supplies coming in from outside districts, since it often happens that, while one district samples all its supplies, the adjoining district does no sampling. *All* supplies must therefore be sampled as part of any routine scheme for examination of milk.

The advantages to be obtained from laboratory control may be summarised as follows :

(*a*) *Milk Producers may be classified into different categories :—*

 (i) Careful and reliable producers. Samples obtained from the supplies of careful producers vary little from quarter to quarter and yield unfailingly good results.

 (ii) Producers who obtain satisfactory results, but who cannot be said to be conscientious. These producers possess the facility for producing good milk with very little effort. Their samples show an occasional unsatisfactory result, which prevents their reliability becoming established.

(iii) Erratic producers whose results vary considerably. These producers can also achieve very good results, but at other times their milk will be found to possess a high bacterial content. They exhibit a sequence of good samples followed by a sequence of unsatisfactory results, generally due to over-confidence in their methods.

(iv) Careless and wilfully neglectful producers. The members of this category understand no argument outside the power of the law or financial penalties, and require constant supervision. They will not learn, and in many countries would be prohibited from selling their product. They should be strictly dealt with upon the occasion of any infringement.

(*b*) *The Distributor has a check upon the article which he purchases.* Routine sampling is of considerable assistance to those dairymen who purchase their milk at some distance from the place at which their business is established. The results enable the dairyman to judge the quality of the article he is retailing, and any unsatisfactory results can be taken up at once with his producer. If after repeated warnings the bacterial quality of the article does not alter, he is able to seek a more hygienic supply. Conversely, reports of satisfactory samples can be used by the producer who sells his milk to a dairyman as evidence of the purity of his supplies. More and more distributors now require evidence as to the purity of supplies which they purchase.

(*c*) *Laboratory examinations yield a true indication as to the quality of the finished article.* With a standardised laboratory technique, this is the only satisfactory method by which the relative value of various supplies can be checked.

(*d*) *The administrative officer is provided with a knowledge of the general level of the milk supplies in his area*, which information will be of considerable assistance to him. Every public health official should be in a position to state the value of the milk supplied throughout the area which he controls and should be enabled to locate accurately any weak points.

(*e*) *The producer is provided with a periodical check upon his methods and upon the methods of his workers, together with an index as to the condition of his equipment.* A producer who works without the aid of laboratory control is operating entirely in the dark. It is certainly a fact that, by means of simple chemical and mechanical tests to be detailed later, he may obtain a rough-and-ready idea as to the quality of his supplies, but he can never hope to obtain complete satisfaction by such methods. With proper laboratory control, milk production and distribution may be checked at all its stages. If no routine sampling is carried out within the district in which he produces, the producer has the advantage of being able to make use of one of the many Agricultural Colleges which will examine his samples at small charge and supply him with advice if requested.

(*f*) *The reports are excellent evidence to use against wilfully careless and dirty producers who may be the subject of prosecution.* The certificates of a bacteriologist over a period of time would certainly be good evidence to bring against such a person.

(*g*) *The public health official can make educative use of the laboratory in many ways.* The producer may be shown the inefficiency of his methods of sterilisation, the pollution which can occur from air, and the manner in which cooling of milk affects the bacterial count, while the distributor may also be educated by similar means.

(*h*) The tuberculin test is admittedly the ideal method to employ for the discovery of tubercular animals, but at the present time the general adoption of such test is remote owing to cost involved. A cheaper and extremely convenient method would be to make use of the laboratory by *methodical examination of all milk supplies for the presence of tubercle bacilli.* If the farmer assisted the work by carrying out frequent clinical examinations of his stock, bi-annual sampling would quickly eliminate animals producing milk containing organisms of tuberculosis.

(*i*) *Specific organisms can be searched for and detected*, if suspicion should arise as to the health of any animal, or if suspicion should be attached to a particular milk supply as the possible cause of a disease outbreak.

Sceptics often ask what useful purpose is served by the routine examination of milk supplies for which there is no compulsory standard. The advantages set out above show that these examinations possess both a practical and educational value and are worthy of continued and increasing practice as a public health measure in addition to any commercial value they might possess.

Unless some standard is fixed to which all ungraded milk might be expected to attain, milk sampling is of little use. Such standards are essential for comparison of results and their absence, other than those fixed by the Milk (Special Designations) Order, 1936, is to be deplored. It is essential, therefore, that some limit should be set beyond which samples should be considered unsatisfactory. Authorities have, therefore, to exercise their own judgment in the matter. That no producer can, at present, be compelled to attain an unofficial standard is not so great a drawback as might at first be thought. Dirty milk means wrong methods, and any producer, given the necessary educational assistance, can, if he wishes, produce milk which will comply with and maintain a suitable standard. Unsatisfactory results mean neglect, and the remedy for consistent neglect is the use of legislation provided. In other words, although action cannot be taken by public health officials upon unsatisfactory reports *per se*, the root causes of contamination as shown by examinations can be dealt with through orthodox channels. A suitable standard would be that at present fixed for Accredited milk or that used for grading under the National Milk Testing Scheme. These are, after all, only clean milks and such a standard should not be difficult to attain or maintain by any producer who is willing to use proper methods or exercise sufficient care. Much non-designated raw milk produced annually attains a higher standard than this, and fixing such a criterion of attainment should cause no undue hardship.

It is inevitable that a point will be reached in all routine sampling when any further increase in the number of satisfactory samples becomes difficult to obtain. It is only by a study of results obtained that the success of efforts being made to control the milk supplies of any district can be judged, and, until all districts pursue a similar course, the milk supplies of the country are likely to remain in jeopardy.

There is no doubt that if local authorities had, in the past, paid more attention to and shown keener interest in the laboratory control of milk supplies and followed up unsatisfactory results with advisory work, much of the agitation for transfer of their duties as supervisors of milk production to the Ministry of Agriculture would never have arisen.

(3) Combined Routine Sampling and Inspectorial Control

There can be little doubt that this is the ideal method to adopt, although it cannot be fully realised in many areas for two reasons :

(*a*) Inadequacy of staff and lack of transport.

(*b*) Time essential to inspect premises and methods and to collect the necessary samples.

Although laboratory control often leads to the detection of improper methods of production, it must be remembered that results do not yield complete information regarding methods of handling the product sampled. The importance of a combination of inspectorial visits and routine laboratory examinations lies in the fact that they serve as a check one upon the other, so that, while neither method is ideal, their usefulness is increased when judiciously combined.

DETAILED BACTERIOLOGICAL EXAMINATIONS

The importance of routine bacteriological examination of all milk supplies is a matter of so great consequence that full details are herewith supplied as to the method of procedure to be adopted for such examinations.

Collection of Samples

It is essential to the proper standardisation of sampling that all samples should be collected in accordance with principles laid down for Designated Milks in Memo. 139/Foods (Jan. 1937) issued by the Minister of Health. Such sampling should include not only non-designated, but also designated milk, irrespective of whether the product is sold loose or in bottles.

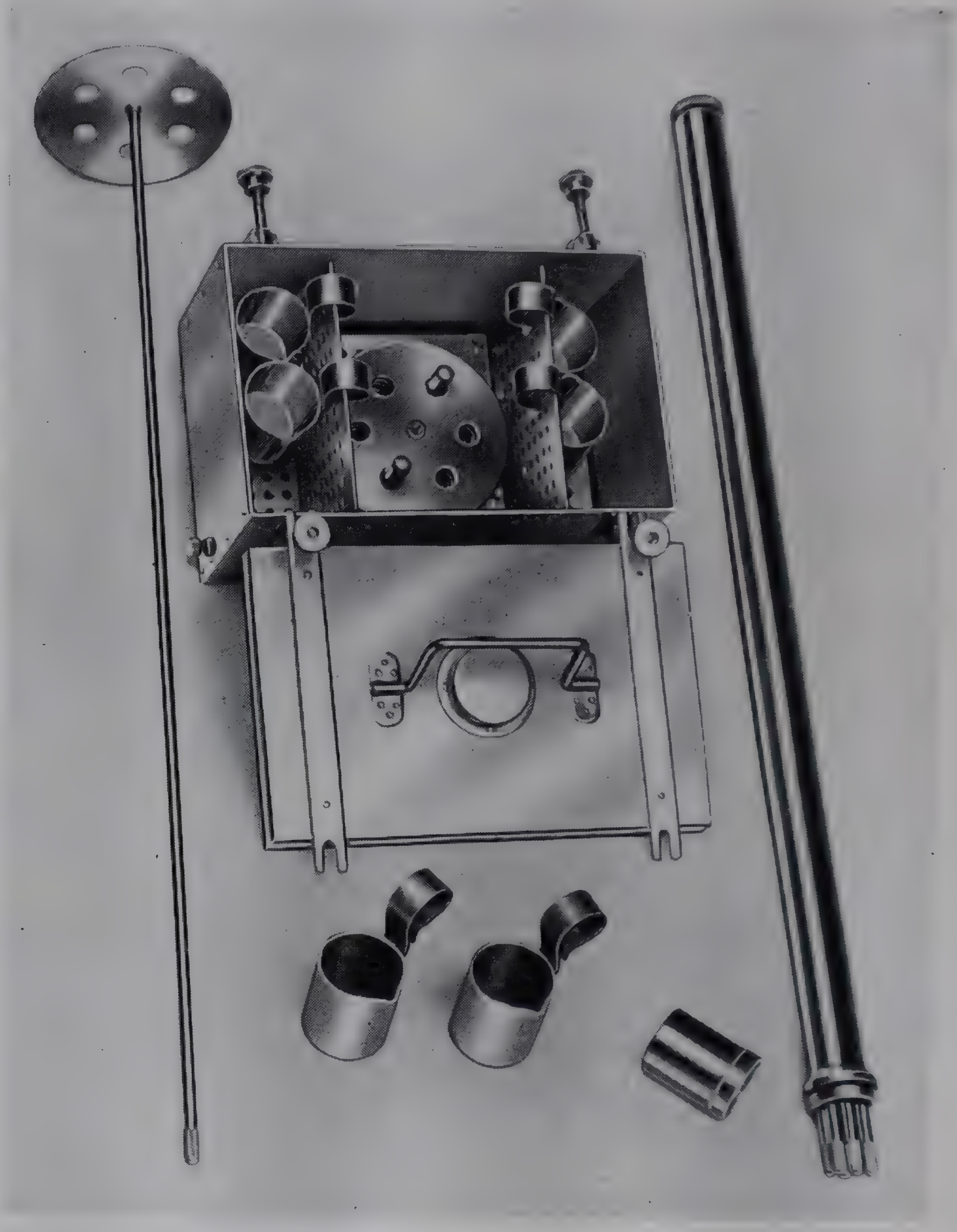
The sampling of *milk in bottles* is comparatively easy. The sample should consist of one container with the seal unbroken, if a seal is provided, either pint or half-pint size according to which is available, although one half-pint bottle is usually sufficient. This sample should be delivered intact to the bacteriologist. Two bottles may be purchased if desired, and their contents mixed in the laboratory. The samples, whether of designated or non-designated milk, should preferably be paid for, although this is not essential, and may be taken at any point between the place of bottling and delivery to the consumer. When the milk has been obtained, it should be packed in ice in a suitable carrying case, and should be kept under these conditions until it arrives at the laboratory. This precaution is particularly essential if the samples have to travel some distance. If the sample is taken at some point near the laboratory, the bacteriologist may dispense with the use of ice if he so wishes, but in summer this precaution should always be taken. In any case, if milk cannot be delivered to the laboratory within fifteen minutes of sampling, ice should always be used except in the case of pasteurised or other heat-treated milks.

The method of collecting samples of *loose milk* depends upon the type of sample required. The usual samples obtained are :

(1) Bulk samples.
(2) Samples from particular herds.
(3) Samples from particular cows.
(4) Samples from separate quarters of the udder.

(1) **Bulk Samples.** In sampling bulk supplies particular care is necessary, and the method of procuring such samples differs considerably from the methods required in obtaining samples of types 2, 3 or 4 above. Bulk supplies are as a rule sampled at collecting depots, railway stations, or dairy premises. In all such instances it is particularly essential that a representative sample should be obtained of any bulk product which is to be examined.

It has been proved that by far the largest number of bacteria are found in bulk milk towards the top of the churn, particularly if milk has been standing for some time. If separate samples are taken from the bottom, middle, and top of a full churn, the sample taken from the top will show the highest bacterial count, while the lowest count will be found in that sample taken from the bottom. It must be understood that the more fat milk contains, the higher will be the count, unless the liquid has been thoroughly mixed before sampling. It is therefore essential that, before samples are taken from bulk supplies in churns, the milk in the churn from which the sample is taken should be thoroughly mixed by means of a sterile plunger. The plunger should be inserted in the milk and plunged upwards and downwards at least ten times. Objections are occasionally raised to a churn being opened for mixing operations. It cannot be denied that on a windy day dust may be blown on to the milk, but there is little danger of the liquid being contaminated in this way on account of the short time during which the churn is uncovered. Further, the number of bacteria which would require to be added to a 10-gallon churn to affect the total count materially would be many more than would normally gain entrance during the few minutes the milk was exposed to air while plunging and sampling were taking place. Any increase from this source may therefore be ruled out of consideration. It should always be remembered that a



By courtesy of Sutherland Thomson & Co.

Fig. 195. "Reigate" Milk Sampling Outfit.

standardised method of mixing milk is as essential as a standardised method of examination.

To collect samples certain apparatus is necessary, as follows :

(*a*) Wide-mouthed glass bottles of 2 fluid ounces capacity. Each bottle should preferably be provided with a metal screw cap which has an inner lining of rubber, though glass stoppers are often provided and are quite satisfactory.

(*b*) Tinned-copper milk dippers contained in a metal case.

(*c*) Metal plungers with detachable or folding handles.

A useful sampling outfit is that shown in Fig. 195. It comprises a portable metal case, which contains both dippers and plungers. No part of the outfit which comes into contact with milk is touched by hand. It will be noted that the dippers are provided with a pouring lip and possess hooked handles to loop over the fingers.

Bottles, dippers and plungers complete in cases are sterilised at the laboratory before use. All testing apparatus should be sterilised in a hot air oven at 160° C. for two hours. Each dipper should not be more than 9 inches in length, and should not be removed from the case until required for use. In many instances, a sterilised dipper provided by the owner is used, but the use of an instrument sterilised in the laboratory is advised. Milk is collected after plunging in sterile glass bottles, which should be fitted with accurately-fitting metal or glass stoppers. A larger quantity than 2 ounces may be obtained if desired and, if this is done, will obviate possible errors in sampling due to uneven distribution of bacteria in the milk. The bottle, after being filled with liquid from the dipper, is securely stoppered and packed in ice in a suitable box constructed to hold four, six, or eight samples, which box, when full, should be immediately forwarded to the laboratory. That portion of the stopper coming into contact with milk should not be allowed to touch any unsterilised object, and only the top of the stopper should come into contact with the fingers. It is important that each bottle should be filled as full as possible in order to exclude the maximum amount of air. Samples of pasteurised or heat-treated milks must not be packed in ice.

(2) **Samples from Particular Herds.** The procedure necessary for obtaining a sample representing mixed milk of all the cows in a herd is somewhat different. The same apparatus is necessary as is used in the collection of samples from bulk supplies. To obtain a really representative sample it is essential that the person collecting this should remove approximately 1 quart of milk from the milking pail after the milking of each cow has been completed, and these portions should be thoroughly mixed in a clean empty churn. The sample should then be taken from the mixed milk.

If desired, each churn representing a particular batch of animals may be sampled separately, provided the milk in every churn has first received a thorough plunging.

(3) **Samples from Particular Cows.** It is often necessary to collect a sample of milk from individual animals, and in doing so great care must be taken to avoid external contamination. The udder and teats of the animal from which the milk is to be sampled should be carefully washed and dried and the milker's hands should also be washed and disinfected. The cow should be milked direct into the bottle, both stopper and bottle being held by the person collecting the sample. The stopper is inserted immediately sufficient

liquid has been obtained. Milk should be obtained from all four quarters, care being taken to ensure that an equal amount is obtained from each quarter of the udder, the fore-milk being rejected before sampling is begun. It is essential that none of the producer's utensils should be used for collection of these samples.

(4) **Samples from Separate Quarters of the Udder.** Suspicion often arises as to the separate quarters of an animal's udder, particularly in dealing with cases of early tuberculosis. In the case of a suspected tubercular udder, it is usually preferable to collect the last milk or "strippings," in which cells and tubercle bacilli are more numerous than they are in fore or middle milk. Various other suspected diseases necessitate the examination of samples of milk from separate quarters, and it may be necessary in certain instances to collect samples of fore, middle, and last milk from one special quarter or from all quarters.

Recording of Particulars

For the information of the bacteriologist and for use by the sampling authority, certain particulars must be carefully recorded, as follows :

(1) Date and time of taking sample.

(2) Particulars of farm or dairy from which sample has been procured. Samples taken from a dairy should, if possible, be accompanied by the name and address of producer.

(3) Particulars as to the milk :
- (*a*) Mixed milk.
- (*b*) Milk from separate herd. Number of cows should be given. Also state whether milk has been strained.
- (*c*) Milk from separate cow.
- (*d*) Milk from separate teat.

  In the case of milk from separate cows or teats, some indication should be given as to the reason an examination is required, and also whether the specimen is fore, middle, or last milk. It is also necessary to state from which quarter or quarters the sample has been procured.
- (*e*) Particulars as to where sample was procured.
- (*f*) Designation of milk (if any).

The time of arrival at the laboratory should be recorded by the bacteriologist or his assistant.

Storage of Samples

This is particularly important when dealing with designated milks. Samples of *Tuberculin Tested* and *Accredited* milks may be either unbottled, being taken from the churn before the container is opened by the consignee or in unopened bottles being obtained prior to delivery to the consumer. It should be noted that the specified bacteriological conditions do not apply to milk, even though obtained from a licensed producer, when it has passed out of his possession and the containers have been opened by the consignee. Samples of unbottled milk should be stored at atmospheric (shade) temperature until 6 p.m. on the day of production if they are from a morning milking and until 10 a.m. on the following day if from an afternoon milking. Bottled milk should be stored under similar conditions for not more than two hours. If it is not practicable to examine samples within the stated time they should be packed in ice or other means of refrigeration should be employed. In the case of *Tuberculin Tested* (*Pasteurised*) and *Pasteurised* milks, bottles should not be packed in ice when forwarded to the laboratory.

Methods of Estimation

There are four methods of estimating the number of bacteria in a given quantity of milk :

(1) Plate Count.
(2) Microscopic Count.
(3) Microscopic Colony Count.
(4) Burri's Smear Method.

(1) **Plate Count.** This is no longer the officially-approved method in general use for the examination of heat-treated milks but it may be used for the bacterial control of final milk quality, and for churn rinse examinations. In addition it is of considerable assistance in controlling the pasteurisation process, particularly in the examination of line-test samples taken at various points in the plant, during treatment. A given quantity of milk or dilution of milk is mixed with liquid medium (standard milk agar) which is poured into sterile Petri dishes and solidifies on cooling. The plates are placed in an incubator for forty-eight hours at a temperature of 37° C., after which the number of colonies is counted. This method has fallen into disuse as a means of examining raw milks although, at one time, it was the standard method employed. It possesses the following advantages :

(*a*) Gives an approximation of the number of *viable* organisms present.
(*b*) Is readily understood by all producers and distributors.
(*c*) Can be used with all types of milk.
(*d*) Allows comparisons to be drawn between each of a series of samples.

It should be remembered that no one culture media is equally favourable for the growth of all species of bacteria. If such a medium could be devised it could not be maintained at a temperature which would be the optimum for all types of organisms found in milk. The oxygen requirements of different species vary considerably and this is an important controlling factor of their rate of growth. The number of *viable* organisms, therefore, in a sample of milk is represented by the number of colonies which will appear on a given medium incubated at a definite temperature, under a fixed set of conditions for a definite period. It is *not* the *total number* of living organisms in the sample. The plate method possesses several disadvantages, the chief of which are :

(*a*) The count does not differentiate between pathogenic, non-pathogenic, or heat-resistant organisms.

(*b*) The count is not accurate, since many bacteria present in a sample of milk do not grow under the prevailing conditions, while rates of growth vary considerably.

(*c*) The numbers of various species of organisms present cannot be separately estimated.

(*d*) The time which must elapse (forty-eight hours) before results of the examination are known is much too long, the milk from which the sample was obtained having been used or processed.

(*e*) The appearance of the colonies gives little idea of their identity or of their influence on keeping quality of the sample in question.

(*f*) The personal factor in examination of samples by this method cannot be ignored, there being frequently a wide divergence in results obtained from an identical sample.

Despite these disadvantages, and they are not the prerogative of this test alone, by this method public health officials have been able to exercise an appreciable and expanding control over the production of clean milk. The numerical standards were readily understood by producers and distributors, and even though they may not have been scientifically correct, the attempt made to reduce and still further reduce colony counts of milk samples has resulted in a great improvement in the quality of the milk supply during recent years.

(2) **Microscopic Count.** This method is in common use in the United States of America and is officially recognised by the American Public Health Association as suitable method for routine bacteriological examination of milk. The test is carried out by spreading 0·01 ml. of milk over an area of 1 square cm. on a glass slide. The material is fixed, the fat removed, and the slide stained with methylene blue or with Newman-Lampert stain and examined under the microscope. The advantages are :

(*a*) Results are obtained at the expiration of half an hour at most.
(*b*) Work of preparing glassware and media is saved.
(*c*) Cost is very low, as no expensive glassware or media are required, while the technique is simple.
(*d*) Slides can be mounted and filed for future reference.
(*e*) Cellular content can be determined and some approximation obtained of types of bacteria present, together with their differential count.

This method is not so satisfactory when dealing with pasteurised milks or with milks possessing low counts as both dead and living organisms are counted, although it may be of value in detecting the presence of thermophilic organisms in pasteurised milk. A further disadvantage is that slides produced from milk which possesses a low bacterial content show so many barren fields that an error is introduced when the average is multiplied by the conversion factor. In addition, the small quantity examined is not representative of the sample. The microscope used in this examination must possess a field standardised to 0·205. To secure the count per millilitre, the average count per field is multiplied by a conversion factor of 300,000. Thirty fields are usually counted and averaged. The test is most valuable when used in conjunction with a plate count.

(3) **The Microscopic Colony Count.** In this method, 0·25 ml. of milk is mixed with 0·25 c.c. of nutrient agar (this is standard agar less milk) on a sterile glass slide, the mixture being spread while warm over an area of 4 sq. cm. The preparation is then incubated in a moist chamber at 37° C. for eight to sixteen hours, thoroughly dried, fixed, and stained with ¼-strength methylene blue. The number of colonies in one microscopic field is counted, and the final result obtained by calculating the number present in 1 ml. The advantages are :

(*a*) A reasonably speedy result is obtained.
(*b*) Possible errors from improper dilutions are eliminated.
(*c*) Cost is low.
(*d*) A permanent record of the count may be obtained.

(4) **Burri's Smear Method.** This is a modification of the plate method, nutrient agar slopes being used instead of Petri dishes. By means of a sterile platinum loop, standardised to hold 0·001 ml., five loopfuls of milk are removed from the sample to be examined. This is smeared over an agar slope, which is incubated at 37° C. for forty-eight hours. After incubation, the colonies on the slope are counted with the aid of a lens. The total number of colonies multiplied by 200 gives the number of organisms per millilitre of milk. This process is not so reliable as the plate count, while it also possesses all the disadvantages of that method.

Dilution of the Samples

As previously mentioned, the accepted method for the examination of heat-treated milks in this country is the plate count. With this method, the proper dilution of samples is of the utmost importance if accuracy is to be obtained. It is also important that milk should be thoroughly shaken before dilution and that dilutions should be well mixed. Milk could, of course, be plated without previous dilution, but difficulties would arise in such cases in ensuring proper separation of the bacteria. Further, if undiluted milk was used for making plate counts, the agar on the plates would be obscured and counting rendered difficult.

Samples of bottled milk almost always fill the bottle to its maximum capacity, this being also the case with many loose milk samples received. As a thorough mixing is essential before the measured quantity of milk used for making the various final dilutions is withdrawn, loose milk samples should be well shaken twenty-five times with a rotary motion of the wrist. About one quarter of the contents should then be poured away and a further shaking for the same number of times with an up-and-down movement of 1 foot excursion should be given. The whole procedure occupies about twelve seconds. If the sample is in a sealed bottle, the milk, after a thorough rotary shaking, should be poured into a larger sterilised bottle and then shaken with an up-and-down motion. Thorough mixing is essential for the following reasons:

(*a*) In order that bacteria may be evenly distributed throughout the sample.
(*b*) To break up any bacterial clumps which may have formed.
(*c*) To mix the cream in a uniform manner.

The differences experienced in bacterial counts of similar samples examined at different laboratories is often due to varying methods of mixing samples, irrespective of incubation period and composition of the media used.

The preparation of the different dilutions depends upon the sample of milk to be examined. For ordinary raw milk samples it is usual to make dilutions of 1 in 10, 1 in 100, 1 in 1,000, and sometimes 1 in 10,000 or 1 in 100,000, but for pasteurised milk only the first three dilutions are necessary. The dilutions are made in standardised $6 \times \frac{3}{4}$ inch dilution test-tubes, plugged with cotton-wool, in measured quantities of distilled water, or preferably sterilised quarter-strength Ringer's solution as follows:

(1) Solution of 1 in 10	9 ml. distilled water plus 1 ml. of milk.
(2) Solution of 1 in 100	9 ml. distilled water plus 1 ml. of No. 1.
(3) Solution of 1 in 1,000	9 ml. distilled water plus 1 ml. of No. 2.
(4) Solution of 1 in 10,000	9 ml. distilled water plus 1 ml. of No. 3.
(5) Solution of 1 in 100,000	9 ml. distilled water plus 1 ml. of No. 4.

Certain precautions are necessary in making each dilution. These are:

(*a*) The pipette should not be inserted more than $\frac{1}{2}$ inch below the surface of the milk or the subsequent dilutions when same is withdrawn.

(*b*) The liquid should be sucked upwards and downwards for ten times to the 1 millilitre mark.

(*c*) The pipette should always be held vertical.

(*d*) The contents of the pipette, after being transferred to the succeeding tube, should be discharged by blowing into the tube, $\frac{1}{2}$ inch above the surface of the diluent.

(*e*) The pipette should not touch the diluting fluid.

(*f*) A fresh pipette should be used for each dilution.

To make the dilutions, sterile, 1 ml. straight-sided pipettes are used. Pipettes used for whole milk should not be used for making any of the dilutions. All new glassware should be first soaked in 1 per cent. hydrochloric acid for several hours, followed by a 1 per cent. caustic soda solution to remove the acid. Glassware should then be washed in running tap-water and finally rinsed in distilled water. Before being used, all glassware should be sterilised in a hot-air oven for two hours at 160° C. to ensure complete destruction of bacteria and spores. In sterilising glassware certain precautions should be observed :

(*a*) The glass should be perfectly dry.

(*b*) The glass should be of even thickness to prevent cracking which will follow uneven expansion.

(*c*) The oven must be cold when glassware is inserted, and should be allowed to cool before the door is opened and the articles removed.

Test-tubes and flasks should be plugged with cotton-wool stoppers before sterilisation takes place, and it is advisable that Petri dishes and pipettes should be wrapped in parchment paper before insertion in the hot-air oven. They should remain wrapped until required.

Preparation of the Media

Two types of media are required for examination purposes :

(1) *Milk Agar Medium* for plates.

(2) *MacConkey Broth* for coliform examinations.

In the preparation of media, all the chemicals employed should be of the highest quality.

(1) **Medium for Plates.** Milk agar medium is prepared from the following ingredients according to directions given in Memo. 139/Foods.

1,000 ml. Tap-water.
5 grams Peptone.
3 grams Yeastrel.
15 grams Washed Shredded Agar.
10 ml. Fresh Whole Milk.

The yeastrel and peptone are dissolved with distilled water in a steamer and reaction at room temperature is adjusted to *p*H 7·4, phenol red being used as the indicator. The agar is wrapped in muslin and washed for fifteen minutes in running cold water. Excess water is then squeezed out and the agar, together with the freshly shaken milk, is added to the broth. The mixture is autoclaved at a pressure of 15 lbs. per square inch for twenty minutes, after which it is filtered while hot through paper pulp in a Buchner funnel, the whole apparatus being kept warm by a surrounding steamy atmosphere. The reaction of the filtrate is tested at 50° C. and adjusted, if necessary, to *p*H 7·0. The medium is then tubed in 10 ml. quantities and autoclaved at a pressure of 15 lbs. per square inch for twenty minutes. The final reaction of the medium at room temperature should be *p*H 7·2. The tubes are plugged with clean cotton-wool, which should be covered with parchment paper to protect from moisture during sterilisation. The medium is faintly opalescent when solidified. It is advisable to test the sterility of media after the process of sterilisation has been completed. This is usually carried out by selecting 10 per cent. of the material at random and incubating for four days at 37° C.

(2) **Medium for Coliform Bacilli.**—This is a liquid medium, and the following ingredients are used in its preparation :

5 grams Sodium Taurochlorate.
10 grams Lactose.
20 grams Peptone.
5 grams Sodium Chloride.
1,000 ml. Distilled Water.

This mixture is steamed for two hours and then transferred to an ice-chest or refrigerator until the following day. It is then filtered while cold through Chardin paper and the reaction adjusted to *p*H 7·4, phenol red again being used as an indicator. Ten millilitres of a 1 per cent aqueous solution of neutral red are added to impart a distinct colour. The medium is distributed into test-tubes each containing an inverted Durham's fermentation tube, 5 ml. of the liquid being placed in each tube. The tubes are finally plugged with cotton-wool and steamed on three successive days for thirty minutes each day, or autoclaved at a pressure of 10 lbs. per square inch for fifteen minutes, following which they are ready for use. The finished medium should be clear and possess a claret-red colour free from any traces of yellow or magenta.

Method of Plating the Samples

Milk is an opaque fluid, so that any attempt to count the total number of bacteria in a millilitre of the fluid would be impossible. When a small quantity of milk is mixed with an artificial media, each organism in the original milk gives rise to an individual colony consisting of innumerable organisms. Each colony can be considered to represent one organism in the original milk, and by this means the numbers may be estimated. Between making the dilutions and plating the samples, not more than fifteen minutes should elapse. Three or more sterile Petri dishes are required, one for each dilution according to the type of sample to be examined. One millilitre of the 1 in 1,000 dilution is transferred to a Petri dish, the cover is replaced, and the same process repeated with other dilutions. The precautions set out on page 365 regarding the handing of pipettes when making dilutions should be strictly practised at this point and, while it is advisable that a fresh pipette should be employed when dealing with each plate, the same pipette may be used for each dilution provided that the plates are inoculated from the highest down to the lowest dilutions. During this process, the tubes containing milk agar media should be boiled and then cooled to 45° C., the melted agar poured over the dilution in the dish at this temperature, and mixed thoroughly while the agar is still liquid. When the medium has been delivered to the dilution in the dish, the whole should be mixed by a combination of rapid circular and to-and-fro movements lasting five to ten seconds. Dishes should stand perfectly level to ensure a uniform depth of medium, and should be allowed to remain in this position for one hour before they are placed in the incubator. When this period has expired, the plates are incubated bottom upwards for forty-eight hours at 37° C. Water-jacketed, gas-heated incubators are to be preferred for incubation purposes although the electrically-operated type are often employed. At the end of this period, each organism in the original milk, which has been fixed in a definite position by the agar, will have multiplied sufficiently to produce a visible colony on the plate. Before the dishes are placed in the incubator, each should be marked with the sample number and nature of dilution contained. When the plates have been poured, steam from the heated media condenses on the glass and condensed water will run on the surface of the media. This moisture is most undesirable and may be removed by drying the poured plates in the incubator for one to two hours, the lids of the dishes being first laid in the incubator and the portion of the dish containing the media being inverted and laid in the incubator so that the free edge rests upon the lid. If care is taken, there is very little risk of contamination of the media from the air. When thoroughly dry, the dishes are inverted and stacked in sixes in the incubator for the requisite period. The apparatus should be opened as little as possible during this period.

Counting the Colonies

At the end of the specified period the plates should be counted as soon as practicable after removal from the incubator. If a long interval must intervene between removal of the plates and counting operations, they should be stored in an ice chest or refrigerator to restrict further bacterial growth.

Counting operations should be carried out by inverting the dish over a counting chart, i.e. a circle divided into sections, two of the sections being further subdivided ; or preferably over a counting desk, illuminated from below. After inversion, the colonies are marked off either with a pen or a special pencil, each section being counted separately. A plate with more than 500 colonies should not be counted unless the plate made with the next higher dilution shows less than 30 colonies. If a plate made from a 1/1000th dilution contains more than 500 colonies it can be inferred that there are more than 500,000 colonies per millilitre of milk. A plate containing less than twenty colonies should not be counted unless it is made from a 1/10th dilution, in which case it can be inferred that there are ten times the number of observed colonies per millilitre. It is advisable to use a lens magnifying 2½ diameters or a low-powered plate microscope for counting purposes.

The high bacterial content of pasteurised milk may be due to :

(*a*) Unsterile equipment.
(*b*) Heat-resistant organisms.
(*c*) Raw milk with excessive bacterial content.
(*d*) Insufficient heating.
(*e*) Re-contamination of milk after processing.
(*f*) Inadequate refrigeration during storage.

Examination for Coliform Organisms

These organisms are not usually present in the udder of the cow, although such occurrences have been recorded, but they are constantly found in the excrement and on dirty, inefficiently cleansed or sterilised utensils. Their detection is the usual complement to other methods of milk examination for estimation of bacterial content and, whatever their source, the presence of these organisms is an indication of faulty production methods and unsatisfactory handling.

The value of the coliform estimation in the bacteriological analysis of water is well attested by years of experience but the fundamental assump-

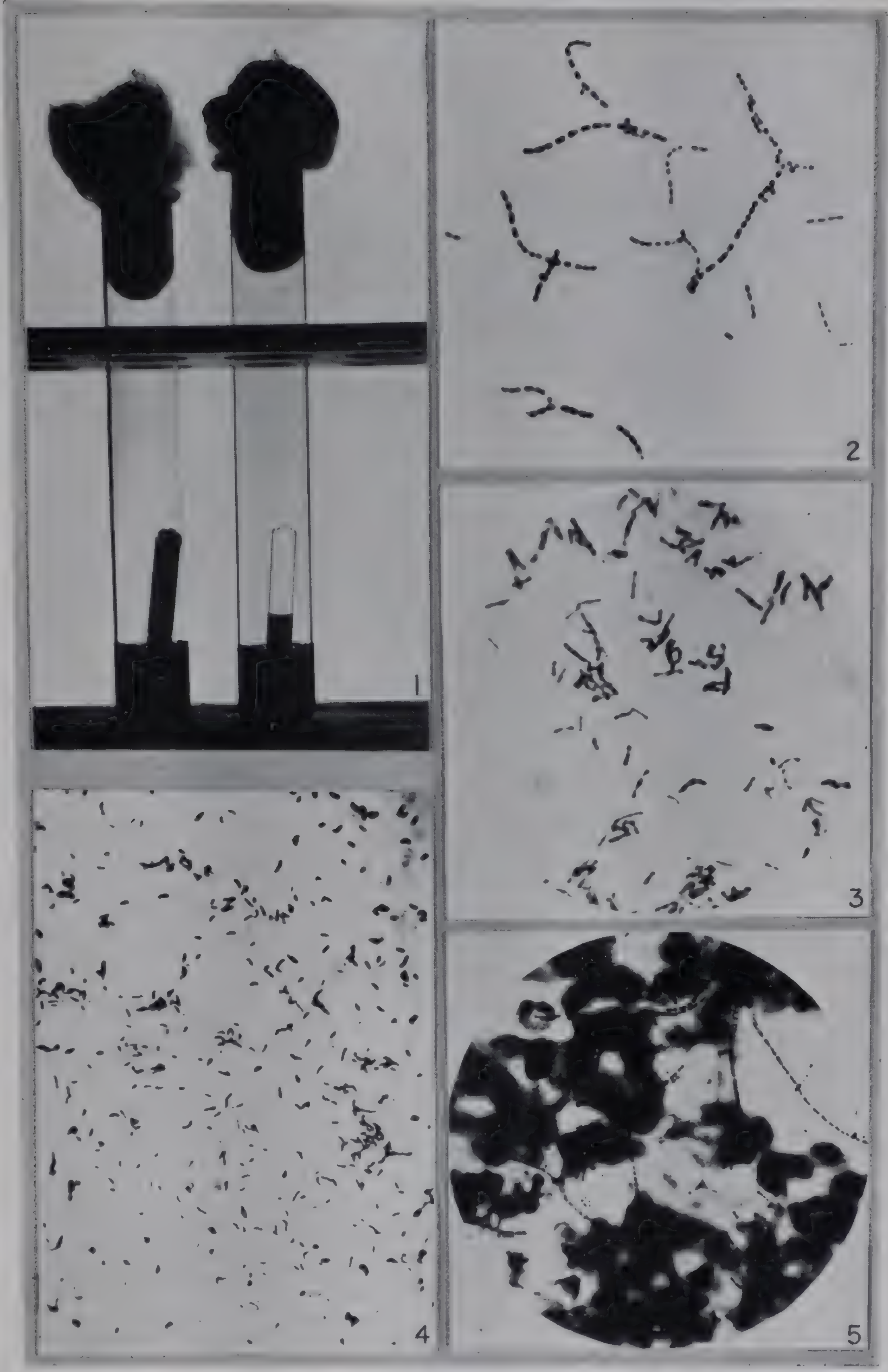


PLATE I.

1. *Bacillus coli*—Formation of gas from lactose. 2. *Hæmolytic streptococci.* 3. *Corynebacterium diphtheriæ.* 4. *Mycobacterium tuberculosis.* 5. *Streptococcus mastiditis.*

[*Facing page* 368.

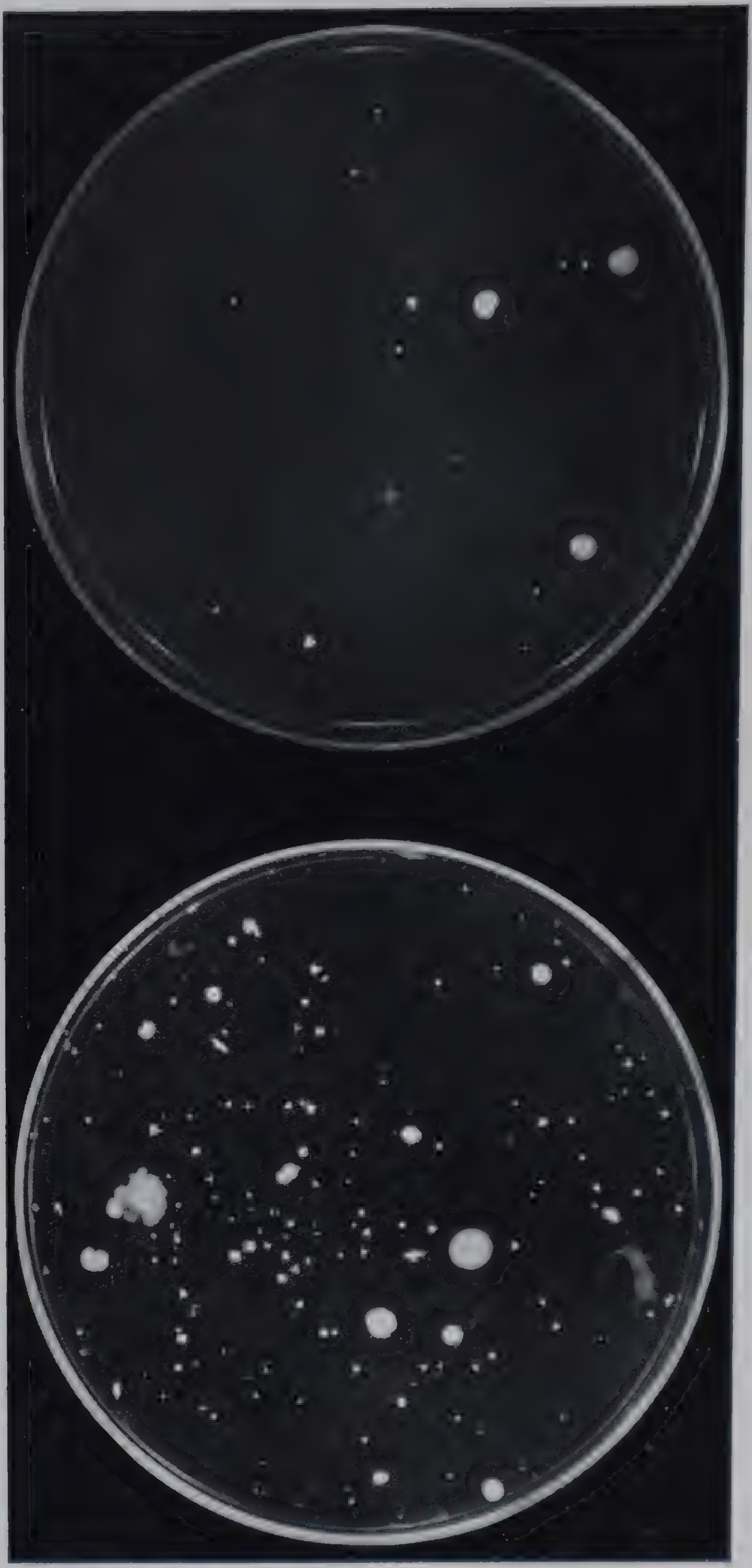


Plate II.
Bacterial Colonies on Agar Plates.

[*Facing page* 350.

tions on which its interpretation is based, do not hold true for milk. The estimation of the presence of these organisms in a sample of milk is a presumptive and not a positive test. In the routine examination of milk, the term " coliform organisms " includes those members of the group which ferment lactose with the production of acid and gas and the method of testing set out below gives a fairly satisfactory presumptive evidence of their presence.

The test for coliform organisms varies according to whether or not the milk to be examined is produced in accordance with the terms of the Milk (Special Designations) Order, 1936. In the case of ordinary milk, the dilutions made for the plate count previously described are again utilised and the same precautions observed during the process. Six double tubes, each containing 5 ml. of the MacConkey broth are required, five of the tubes being inoculated as follows :

Tube 1.	1 ml. of milk.
Tube 2.	1 ml. of the 1 in 10 dilution.
Tube 3.	1 ml. of the 1 in 100 dilution.
Tube 4.	1 ml. of the 1 in 1,000 dilution.
Tube 5.	1 ml. of the 1 in 10,000 dilution.

One tube, used as a control, is left uninoculated, but is incubated with the others. The tubes are incubated at a temperature of 37° C. for forty-eight hours and are examined for acid and gas at the end of that period. If coliform organisms are present, the medium will have changed to a bright pink colour, and gas will be present in the inverted fermentation tube. The tubes may be removed from the incubator if gas is present in all of them before the end of the forty-eight hour period. Each tube is marked with the number of the sample and the dilution contained.

The estimation of the coliform content of designated milks is carried out in a different manner as regards the inoculation of tubes. For " Tuberculin Tested " and " Accredited " milks, three tubes are each inoculated with 1 millilitre of the $\frac{1}{100}$th dilution of the milk. An uninoculated control tube is again incubated. Milk is regarded as satisfactory if two out of three tubes are found to be free from acid *and* gas after forty-eight hours incubation.

The test for coliform organisms is, however, one of the best means of controlling efficiency of pasteurisation, and it is to be regretted that the bacteriological standard laid down for milk processed under the terms of the Milk (Special Designations) Orders, 1936 to 1946 makes no mention of its employment for this purpose. Tests of this type are often made, 1 millilitre or 0·1 millilitre of the liquid being examined, but this is a useless procedure unless the milk is taken direct from the apparatus. For samples obtained during delivery, much larger quantities must be used if a true indication of faulty processing or after-recontamination of the milk is to be obtained and a suggested and useful standard would be that not more than one tube should be positive out of three tubes each containing 10 millilitres of milk for samples of this type. This test is useful mainly on the positive side but a negative result does not, however, indicate that the process is efficient.

Examination for Thermophilic Bacteria

Thermophilic organisms may be detected by means of the methylene-blue reductase test described on pages 378 to 383 modified as regards temperature. Milk with added methylene blue solution is incubated at a temperature of 55° C. If the milk is heavily contaminated with these organisms reduction of methylene blue will occur within three hours. The direct microscopic method detailed on page 364 may be used to detect thermophiles in milkstone or milk film and to check milk as it passes through the plant. The majority of thermophilic organisms are long bacilli which are readily identifiable. The plate count may also be employed to afford an estimation of these organisms if carried out at a temperature of 55° C immediately after milk has been processed.

Examination for Thermoduric Bacteria

The following method for the laboratory examination of raw milk and for the detection of thermoduric organisms may be employed. A standard loopful (0·01 ml.) of the sample to be examined is transferred to 4 ml. of melted nutrient agar (containing all ingredients of standard agar except milk) at a temperature of 45° C. in a cotton stoppered, oval, test-tube. The whole is mixed together and the tube is placed in a slanting position so that the agar slope is about 3 inches long. The tubes are then incubated at 37° C. for forty-eight hours, when the colonies are counted. Counts obtained in this way from samples of milk before and after laboratory pasteurisation serve to detect those samples which contain thermoduric organisms.

The method of *laboratory pasteurisation* suggested by Anderson and Meanwell demonstrates whether or not the milk so treated contains large numbers of organisms likely to resist the pasteurisation process. Milk is treated in the following manner. Five millilitres of the sample to be examined are placed in a sterile test tube, care being taken to ensure that the liquid does not touch the upper portion of the inside of the tube. A cotton-wool plug is inserted and the tube with its contents are incubated in a water-bath at a temperature of 63° to 65° C. for thirty-five minutes, the water level in the bath being maintained at least 1 inch above the level of the milk in the tube. Following incubation, the tube and its contents are cooled in running water and plate counts of the milk before and after incubation are made in the usual manner.

Cell Counts

Cell counts of milk may afford valuable evidence of disease in any particular animal although their value is limited by the fact that milk sold to the consumer is generally the mixed product of a number of animals. There are several methods employed, the two most important being:

(1) Microscopic Method.

Milk is examined under the microscope, the number of cells being counted in a given quantity of the liquid.

(2) Centrifuge Method.

The number of cells present in a sample of milk are concentrated by centrifuging and the number present in a definite volume of the concentrate estimated.

The microscopic method gives a more accurate count as during centrifuging a certain number of cells are carried off in the cream, therefore a count taken of the sediment is not accurate.

During the last few years a method for the determination of efficient pasteurisation has been developed, based upon the condition of the cells. Milk is mixed with methylene blue stain and the mixture centrifuged. The stained cells are easily found if a smear is made and examined under a microscope. In milk which has been properly pasteurised, the cells are well stained, the compact masses of nuclei being darkly pigmented against a lighter background. In raw or improperly pasteurised milk cells appear unstained and form clear areas against a darkly-coloured background.

Churn Rinsing Tests

These tests are now a normal procedure under the National Milk Testing and Advisory Scheme in order to check cleansing and sterilisation of churns at collecting and processing depots.

Five hundred millilitres of sterile quarter-strength Ringer's solution is poured into the lid of the churn to be tested. The lid is washed with the liquid and replaced, the churn laid on its side and it is then rolled twelve times. It is allowed to stand for five minutes and rolling is repeated. The rinse is poured into a sterile container and tested by the plate count. The number of colonies per churn is ascertained by multiplying the number of colonies per millilitre of the rinse by 500. Results are classified as follows :

Colonies per churn	Classification
Under 50,000	Satisfactory.
50,000 to 250,000	Fairly satisfactory.
Over 250,000	Unsatisfactory.

If the interior of a churn is wet before the test is carried out, it will be classified one grade lower than the colony count indicates. Churns tested in this way should be selected at random from each batch treated. If detergent and other factors are satisfactory, unsatisfactory results obtained by these examinations are probably due to recontamination after treatment, usually by the final rinsing water.

Pathogenic Organisms in Milk

The presence of definite pathogenic organisms in milk arising from diseased conditions in the body of the animal requires most careful consideration. The most general and important examination of this type is that made for the presence of the bacillus of tuberculosis, although on occasion it may be necessary to examine milk for the presence of other pathogenic organisms such as *Streptococci*, *Brucella abortus*, *Bacillus typhosus*, and *Corynebacterium diphtheriæ*.

Examination for Tubercle Bacilli

The examination of milk for the presence of tubercle bacilli is an essential part of all milk control work. None will deny when the effects due to infection by such organisms on human beings, especially children, are considered, that it is extremely important their presence in milk should be detected as speedily as possible. The microscopic method is most rapid and a fair number of positive cases may be discovered by this means, but the most satisfactory method of detection is animal inoculation.

One hundred millilitres of the sample to be examined is divided into four equal portions, and these are centrifuged for half an hour at a speed of 3,000 revolutions per minute. When this process has been completed, the tubes are removed from the machine. The cream layer is separated from each tube, following which the supernatant fluid is gently decanted, leaving the sediment, i.e. the essential portion, behind. Centrifugalisation causes the bacilli to fall to the bottom of the tube, though, on rare occasions, a few may be found to have risen with the fat. The sediment from each of the four tubes is carefully decanted into a smaller tapering centrifuge tube under sterile conditions, and is re-spun for fifteen minutes at a similar speed to that employed on the first occasion. The liquid obtained is again decanted and the sediment mixed with sufficient sterile saline to produce an emulsion of 3 ml. capacity. This emulsion is drawn into a sterilised hypodermic syringe for inoculation into a guinea-pig.

The value of the guinea-pig in detecting the presence of the tubercle bacillus in milk cannot be over-estimated. Two guinea-pigs are prepared by clipping the hair from a portion of the internal surface of the left thigh, the bared site being afterwards cleansed with methylated spirit. An inoculation at this site is chosen, not only for the sake of convenience, but also because injection at this point enables an earlier diagnosis of the disease to be made, palpation of the associated lymph glands being facilitated. Some workers favour intra-peritoneal inoculation, choosing the mid-line of the abdomen as the site of injection. The drawback to this choice is the fact that, if the milk contains pathogenic organisms other than tubercle bacilli, the guinea-pig is less likely to withstand general infection, absorption taking place much more readily from the peritoneal cavity than from the subcutaneous tissue of the thigh.

The site of inoculation having been prepared, the animal is securely held by an assistant who controls the three legs other than the one into which inoculation is to take place. The person making the inoculation grasps the thigh in the left hand, close to the proposed site, inserts the needle under the skin and injects 1·5 ml. of the prepared solution into the subcutaneous tissue. The needle is withdrawn, and the thumb of the left hand pressed over the site of inoculation to prevent any exudation of emulsion. The remaining 1·5 ml. is injected into a second guinea-pig of similar size and weight. An identification card is prepared for each pig, giving the following particulars :

(1) Colour markings and sex of animals, together with site of inoculation.
(2) Date of inoculation.
(3) Notes of any incident during experimental life of the animal.
(4) List of weekly weights, which affords a guide to the health of the animal.

The two inoculated guinea-pigs are housed together and fed normally for six weeks. During the entire period they should be weighed and examined clinically at weekly intervals. The left groin is inspected for abscess or pus formation or for enlargement of lymphatic glands, the latter being detected by palpation. In the case of pus formation, some of the material is withdrawn and examined for the presence of tubercle bacilli. If these are found to be present, the guinea-pig is killed, and a post-mortem examination immediately performed. Failing an early diagnosis, the first pig is killed at the expiration of six weeks by means of prolonged chloroform anæsthesia or by a sharp blow upon the back of the neck. A detailed post-mortem examination is then made. The site of inoculation and the local glands are carefully examined for tuberculous lesions. The liver and spleen are also similarly examined and, if lesions are present, smears are made on clean slides, stained in the appropriate way (see page 373), and examined microscopically. If the result is negative, the second pig is killed after a further two weeks, the same procedure being adopted. The technique set out above may be varied in minor details, but the general principle should remain unaltered.

The disadvantage of this type of examination is the period which must elapse before a definite result is obtained, the delay preventing possible administrative action being quickly taken. In the case of a positive bulk sample, necessitating group and individual samples, a period of three to six months may elapse before the affected animal is found. Further, this animal may have been sold before a result is obtained. It is not an uncommon experience for one of the guinea-pigs to show a positive result while the other gives a negative indication. This being so, it is quite possible also that both animals may sometimes show a negative result, although the milk may be infected with tubercle bacilli. This delay may be obviated by making use of a direct microscopic examination of centrifugalised deposit. A result is obtained by this means within a short time, but the method is of little use in the case of bulked milk supplies, when it can never take the place of inoculation. In the case of samples from single animals or from separate quarters of the udder, the method is of considerable value. For microscopic examination, the material to be studied is smeared on a glass slide, dried, and fixed by heat. The process of staining is as follows :

(1) Flood the slide with filtered carbol fuchsin. This may be applied hot from a test-tube or may be heated on the slide at intervals. The smear is allowed to stain for fifteen minutes and the stain must not be allowed to dry on the slide.

(2) Wash well with water.

(3) Immerse the slide in 20 per cent. sulphuric acid. After a minute's exposure to the acid, wash with water and replace in the acid, repeating the process several times. Decolorisation is complete when the smear appears faintly pink after the final washing.

(4) Wash well with water.

(5) Treat the slide with alcohol for two minutes.

(6) Wash again with water.

(7) Counter-stain with Loeffler's methylene blue or 1 per cent. malachite green for at least thirty seconds.

(8) Wash and dry thoroughly.

It is advisable to treat the slides with ether for some hours before they are stained, to remove the fat.

The bacilli show as bright red rods, while the background of tissue cells and other organisms is stained blue or greenish-blue. A negative result does not entirely exclude the presence of tubercular bacilli, as the organisms may be present in such scanty numbers as to escape detection. Tubercle bacilli in milk may be concentrated by means of trypsin digestion, following the method described by Douglas and Meanwell.

In this process, 10 ml. of milk are mixed with 0·5 ml. of trypsin solution in a centrifuge tube provided with a screw stopper. The tube is incubated for six hours at 37° C., and, after cooling, 5 ml. of ether are added to the tube which is then sealed and thoroughly shaken. The tube is centrifuged for twenty minutes at 4,000 revolutions per minute, the liquid forming three layers. Into the centre gelatinous layer, which contains all the acid-fast bacteria, a platinum loop is inserted, and, after withdrawal, the contents are smeared on a slide which is dried at room temperature. When thoroughly dry the slide is inserted into alcohol and ether for two hours, after which it is stained and examined in the manner described above.

The fact that the presence of human tubercle bacilli in sputum can be more certainly and speedily discovered by the cultural method, has led to efforts being made to apply this technique to milk. Some success has been attained, but up to the present it has only been found successful in dealing with milk from single animals or small groups. This method has shown that samples, apparently negative when microscopically examined, were really positive. As a result is obtained in ten to fourteen days, it would appear that success on these lines would be of considerable assistance to those engaged in milk control work.

Examination for Streptococci

Streptococci are found in varying numbers in milk but, except for those discovered in conjunction with certain definite circumstances, they are usually of little import. Streptococci are present in case of acute mastitis in the cow, and as a rule are then readily detected by the fact that, when a sample of milk is centrifuged, there will be a thick deposit of pus which may or may not be intermixed with blood. A portion of this deposit is smeared on a microscopic glass slide, fixed by heat, stained with methylene blue or by Gram's method and examined. The sediment in tubes which fail to pass the Resazurin test (see page 383) when smeared on a slide and examined under the microscope, quite often shows the presence of streptococci. Staining with methylene blue solution is required. Alternatively, the organism may be grown on ordinary agar or blood serum medium. The colonies after incubation may be picked off and smeared on slides, stained and examined. This organism, when discovered in conjunction with blood and pus, should always be regarded as a pathogenic factor and therefore a consequent potential danger to consumers of infected milk.

The significance of the presence of streptococci in milk may be summarised as follows :

(1) Their presence in excess is a definite indication of pollution of an undesirable type.

(2) If they are exceedingly numerous, they point to some undetected pathological lesion in the cow.

(3) Certain types are definitely pathogenic to man.

Brucella abortus

It is still an accepted and approved veterinary practice in certain districts to inoculate cows with a prophylactic vaccine composed of living *Brucella abortus*. The presence of this organism in a sample of milk may therefore be due to the vaccine used and not to natural infection of the animal. In either case it is liable to produce a type of undulant fever in man which is difficult to diagnose. The organism does not grow on ordinary culture media without special precautions, nor can it be detected by ordinary bacterial plate counts. Investigation should be carried out by means of an agglutination test. The sediment obtained for the examination of tubercle bacilli will, if the organism of contagious abortion is present in the sample, introduce the organism into the system of the guinea-pig, in the blood of which it can be detected. Approximately 2 ml. of blood are collected. This is either allowed to coagulate or is centrifuged to obtain the serum in which the antibodies are present. The serum so obtained is set up in a series of tubes in increasing dilutions with sterile saline solution commencing at one-fifth and rising to one three hundred and twentieth. The volume of diluted serum in each tube is 0·5 ml., and to this is added an equal amount of a suspension in carbol saline of killed organisms of a similar type. The tubes are incubated at a temperature of 37° C. for twenty-four hours, and readings then taken. If the blood contains agglutinins, the tubes will be seen to contain a clear fluid, the agglutinated organisms having fallen as a deposit. The highest dilution showing this change is the end point of the reaction. As the serum of normal animals may exert some degree of agglutinative influence, only results in which agglutination occurs in dilutions over 1 in 40 should be accepted as indicating a positive result.

The organisms may be isolated from infected milk in the following manner. Fifty millilitres of milk are centrifuged, the supernatant liquid decanted, and 1 ml. of sterile water added to the sediment. One, two, five, and ten loopfuls of the liquid are added to tubes of melted 15 per cent. liver agar containing 1 in 200,000 gentian violet, the contents of each tube being poured into Petri dishes. The inoculated plates are placed in a sealed container in which 5 to 10 per cent. of the air has been replaced by carbon dioxide, and are incubated for four days at 37° C. Small transparent colonies appear which may be picked off and examined. After continued cultivation the organisms may be grown under ordinary atmospheric conditions.

Bacillus typhosus

To detect the presence of this organism, the sediment obtained after centrifugalisation is plated out on the surface of MacConkeys' bile-salt neutral-red agar, when colonies of the *Bacillus typhosus* will appear as paler units in contrast with the more usual pink colonies of *Bacillus coli*. It is essential that the surface of the media should be thoroughly dry before inoculation is made. The plates are incubated until suspicious colonies appear, usually at the end of eighteen to twenty-four hours. If no colonies appear after this period, the plate should be incubated further. When colonies appear, several are subcultured on agar slopes. The pure cultures when isolated are then subjected to fermentation tests. The following table shows the method by which typhoid and paratyphoid bacilli and organisms of the coli group may be distinguished :

TABLE 17

	B. typhosus.	*B. paratyphosus.*	*B. coli.*
Lactose . . .	No change	No change	Acid and Gas
Glucose . . .	Acid only	Acid and Gas	Acid and Gas
Mannite . . .	Acid only	Acid and Gas	Acid and Gas
Dulcite . . .	No change	Acid and Gas	Acid and Gas
Maltose . . .	Acid only	Acid and Gas	Acid and Gas

Corynebacterium diphtheriæ

To examine milk for the presence of this organism, Lœffler's serum slopes are inoculated with the sediment obtained after centrifugalisation. The cultures are incubated for eighteen to twenty-four hours at 37° C. and films are then prepared, stained, and examined. The best and simplest stain to use for this purpose is a rectified toluidine blue (Pugh's stain) which acts within several seconds.

Office Records

Office records and the notification of examination results to producers and distributors are of considerable importance. The immediate recording of particulars of samples is essential, and a complete record of every sample from each separate supply entering a particular district should be kept. The card illustrated has been found by the writers to be of considerable value in this respect. The cards should be filed either alphabetically or in name order, so that they may be available for instant reference.

FRONT

LABORATORY EXAMINATION OF MILK

Producer.. Address..

Retailer.. Address..

No. of cows.......................... ....Milk. No......................

Particulars.	Sample Nos.					
Date of sample . . .						
Time obtained . . .						
Where obtained. . .						
Examined by . . .						
Result received . . .						
Reductase test . . .						
Resazurin test . . .						
Phosphatase test . .						

BACK

Particulars.	Sample Nos.					
Tubercle Bacilli. . .						
Total Bact. Count per ml. .						
B. coli present in . .						
Butter Fat % . . .						
Specific Gravity. . .						
Non-fatty Solids . .						

Remarks ....
....
....
....

Results should be notified to the distributor if the sample has been obtained from this source. The name and address of the producer, if these are known, should also be added. The producer who retails his own milk should be notified if the sample is obtained direct from him. The type or grade of milk, raw, sterilised, etc., should be stated on the report. Copies of reports applicable to this purpose are set out on pages 377 and 378.

Unsatisfactory results in locally produced samples should be immediately followed up by a visit to the point of production and a thorough inspection made of premises and utensils. In many instances it will be found that handling is at fault and that utensils have not been properly sterilised. Whether the fault be transient or permanent, the cause of contamination as evidenced by the laboratory report should receive adequate attention.

COPY OF REPORTS SUITABLE FOR NOTIFYING RESULTS OF LABORATORY EXAMINATIONS TO PRODUCERS OR DISTRIBUTORS

No. 1

Dear Sir(s).

EXAMINATION OF MILK

I have to inform you that a sample of milk obtained from you at........................
....
...., on ....
has now been examined, and the following is the result of the examination.

Sample No. ....
*Total bacterial count :— ....bacteria per millilitre.
*Bacillus coli present in :— ....of a millilitre.
*Methylene-blue reductase test. Sample not decolourised in.........hours.
Sample decolourised in .... hours.
*Resazurin test. Disc reading............
Category ....

Remarks :—

Yours faithfully,

Medical Officer of Health.

To...................................
....
....

* Cross out if inapplicable to any particular sample.

Check samples should be taken in cases of doubt, with a view to elucidating the source of contamination. The obvious points at which such samples should be obtained are :

(1) **Producers' Premises**
- (*a*) Immediately after milking.
- (*b*) Before cooling but after straining.
- (*c*) Immediately after cooling.
- (*d*) Immediately before despatch.

(2) **Distributors' Premises**
- (*a*) On arrival from the producer.
- (*b*) After cooling.
- (*c*) After bottling.
- (*d*) Before delivery.

A combination of two check samples, i.e. before and after cooling, may show that an inefficiently-cleansed cooler is the cause of a high bacterial count.

Further unsatisfactory samples should be notified to the local authority of the district in which the milk has been produced, with a request that steps be taken to secure an improvement in the supply. The results of examinations for the presence of tubercle bacilli, if positive, should also be reported to the appropriate authority, in order that subsequent veterinary inspection of the herd may immediately follow.

For all raw designated milks, a different type of form is required, a copy of which is reproduced below. Unsatisfactory results of designated samples should be immediately reported to the authority responsible for issuing producer's licence. In all cases of unsatisfactory samples, further check samples should be taken some two weeks after the result of the first sample has been notified to the person concerned. These samples should always be taken in similar conditions to those prevailing under which the first samples were obtained.

No. 2

Dear Sir(s),

BACTERIOLOGICAL EXAMINATION OF DESIGNATED MILKS

I have to inform you that a sample of milk obtained from you at.......................
....
...., on ....
has now been examined, and the following is the result of the examination.

Report of Bacteriological Examination of :—

$$\left.\begin{array}{l}\text{*" TUBERCULIN TESTED "}\\ \text{*" TUBERCULIN TESTED (Certified) "}\\ \text{*" ACCREDITED "}\\ \text{*" ACCREDITED (Farm Bottled)}\end{array}\right\}\text{MILK}$$

Sample No............

Sample complied (did not comply) with the methylene-blue reductase test.

Presence or absence of coliform bacillus in one-hundredth of a millilitre (each of three tubes) after 48 hours' incubation :—

Tube 1.................
Tube 2.................
Tube 3.................

Remarks :—

I am of opinion that the sample $\frac{\text{complied}}{\text{did not comply}}$ with prescribed conditions.

Yours faithfully,
Medical Officer of Health.

To..................................
....
....

* Cross out if inapplicable to any particular sample.

A similar form should be used for the notification of results of examinations of "Tuberculin Tested (Pasteurised)" and "Pasteurised" milks except that the result of the phosphatase test must be stated, in addition to compliance or non-compliance with the methylene-blue reductase test. Examination for coliform content not being prescribed by the Order, the result of any such test should, if carried out, preferably be notified under the heading of "Remarks."

Methylene-Blue Reductase Test

On the Continent and in the United States of America, this method of testing has been used for a good many years as a means of assessing the bacterial quality of milk and as a result of the work of Wilson and his colleagues, a modified form of test has been officially adopted for the examination of samples of Tuberculin Tested and Accredited milks, the technique being set out in Memo. 139/Foods. The majority of organisms in milk are capable of altering the oxidation-potential of the liquid to a point at which the colour of certain dyes, such as methylene blue, is discharged. The rate at which this change takes place varies considerably and is related to the species of organisms present, their rate of growth and activity at any one temperature. Generally speaking, it may be stated that the greater number of organisms in a given quantity of milk and the more active they are, the shorter will be the time required for the reduction of the dye. It should always be remembered that this test is *not* a method of enumerating the bacterial population of a sample of milk, but is rather *a test of the activity of that population* at any particular time.

The *apparatus* required consists of :—

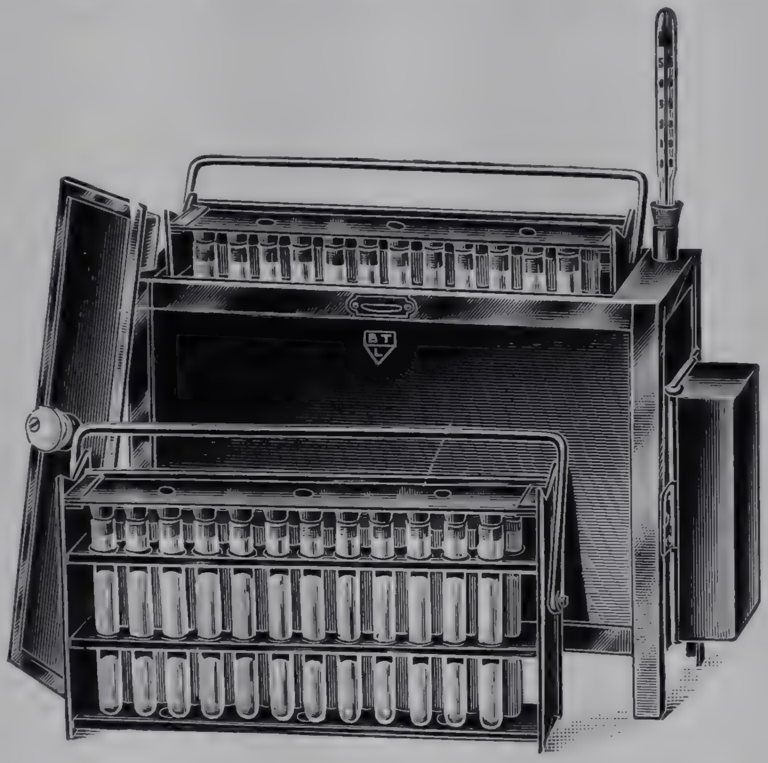
(*a*) An automatic temperature-controlled water-bath constructed of copper. This may be heated by oil, gas or electricity and its temperature must be maintained between 37° and 38° C. by means of a thermostat. The interior of the bath must be completely dark and it should be fitted with a test-tube rack, numbered for identification purposes and provided with a metal cover (see Fig. 196).

(*b*) Test-tubes possessing an etched mark at the 10-millilitre level, and fitted with aluminium caps. These require to be sterilised in a hot air oven at a temperature of 160° C. for two hours.

(*c*) Rubber stoppers for sealing the tubes during the test. These must be sterilised in boiling water immediately before use.

(*d*) One-millilitre, straight-sided pipettes which should be plugged with cotton wool, wrapped in Kraft paper and sterilised in a similar manner to the test-tubes.

(*e*) Methylene-blue solution. This is prepared from standard methylene-blue tablets, one tablet being dissolved in 200 millilitres of cold, sterile, glass-distilled water in a sterile flask. The flask and its contents should be well shaken to dissolve the tablet, following which sufficient sterile distilled water is added to bring the quantity of solution up to 800 millilitres. The flask should be sealed with a rubber stopper to prevent evaporation and stored in a dark place. Solutions over two months old should not be used. After the solution has been made up, its sterility should always be checked while such further tests should be made at frequent intervals.



By courtesy of Baird and Tatlock, Ltd.

FIG. 196. Reductase Bath.

The *technique* of the test is as follows : The sample to be examined should be well mixed by inversion and shaking. The stopper and mouth of the sample bottle should be flamed along with the test-tube, well-mixed milk being poured rapidly in until the liquid reaches the 10-millilitre mark of the test-tube, one side of the tube being left unwetted. One millilitre of methylene-blue solution is then added by means of a pipette, and the pipette should touch neither the milk nor the side of the tube. The tube is sealed with a sterile rubber stopper, care being taken to see that the fingers do not touch the mouth of the tube. The tube and its contents is then twice inverted slowly and is immediately placed in the water-bath. Two control tubes are required for each batch of sample tested. One of these contains 10 millilitres of mixed milk from several samples plus 1 millilitre of tap water and the other should contain 10 millilitres of mixed milk plus 1 millilitre of methylene-blue solution. These tubes are fitted with stoppers and are immersed in boiling water for three minutes in order to destroy the reducing properties of the milk. Control tubes are required to denote commencement of decolourisation and completion of this change. The tubes are inspected at half-hourly intervals, care being taken to ensure that they are not exposed to direct sunlight and any tube which has lost its colour should be removed. Tubes which are in the process of decolourisation should be allowed to remain while the others should be inverted once. Inversion is important as without it the cream content would not be distributed as evenly as possible throughout the liquid. If allowed to collect upon the surface of milk, the reduction period will be delayed. A common method of examining tubes is to inspect the whole rackful *en bloc,* but if this is normal practice slight changes of colour may not be observed, especially if inspections are made by artificial light. For this reason, each tube should be lifted individually for inspection, alongside control tubes, in a good light. Milk is regarded as decolourised when the whole column of liquid has lost its colour or is decolourised up to within 5 mm. of the surface. The time at which milk is decolourised is noted but if no change has occurred within the prescribed time, the sample complies with the test. The periods laid down as demonstrating a satisfactory sample are failure to decolourise in four and a half hours between May 1st and October 31st, or in five and a half hours between November 1st and April 30th.

It should be noted that milk from Channel Islands cattle and some other breeds may, when being tested, exhibit a different shade of blue than is normally the case, so that it is necessary to set up control tubes from the same highly-coloured milk.

This test may also be used for grading milk, if desired, as shown in the table below :

TABLE 18.

Result of Test.	*Regarded as:*	*Grade.*
Reduced in 15 minutes	Unsatisfactory	Very bad.
,, ,, ½ to 1 hour		Bad.
,, ,, 1½ to 2 hours		Poor.
,, ,, 3 to 4 hours	Doubtful.	Doubtful.
,, ,, 4½ to 6 hours	Satisfactory.	Good.
Not reduced in 6 hours		Very good.

In carrying out the test, certain *precautions* must be strictly observed. These are :

(1) The interior of the water bath must be kept dark.

(2) Its temperature should be checked at frequent intervals during the tests.

(3) Thermometers used on water-baths should be checked at monthly intervals.

(4) Water-baths should be cleaned out at weekly intervals and fresh water added.

The test possesses the following *advantages :*

(1) The quality of a given sample may be determined within a few hours.

(2) It can be carried out by any intelligent person.

(3) Control can be exercised where laboratory facilities are limited at low cost.

(4) It is fairly fool-proof if the precautions set out above are strictly observed.

In spite of official approval to its employment, the test is not perfect, possessing certain *disadvantages*, viz.:

(1) The temperature at which milk is held (37° C.) is not the ideal temperature for the growth of all types of organisms present, therefore the reduction period does not give a true indication of their activity.

(2) It is primarily a process for testing raw milk, although if employed for examination of the pasteurised product prior to delivery to consumer it can be useful for assessing degree of re-contamination or adequacy of cooling after treatment. If the test is carried out at a temperature of 55° C. it may be used as a means of detecting the presence of thermophilic organisms.

(3) The test is not sufficiently sensitive to allow of any close differentiation between different grades of milk and does not provide a test of milk of individual animals.

(4) It is reported from a variety of sources that results obtained may be affected markedly by the temperature to which milk is exposed and time of keeping.

(5) It is an " all-or-nothing " test, milk either reducing the dye completely and being rejected or no reduction takes place, the milk being passed. No latitude is allowed for the laboratory report to be assessed in the light of conditions prevailing at the farm.

Although the test has received considerable criticism, it is much cheaper to carry out than is the plate count while, generally, it may be stated that the accuracy of this method and that of the plate count are about equal. It must also be mentioned in considering this test that milk which contains large numbers of mastitis streptococci does not readily undergo decolourisation except when large quantities of pus cells are present in addition. Streptococci appear to have little action on the dye and any rapid decolourisation which may occur is due to cellular elements present. As a result, samples from cows possessing latent infections of the udder are not likely to fail to comply with the prescribed standards when methods of production at the farm are such as to preclude extraneous contamination.

The employment of the methylene-blue test in the examination of raw, designated milks has tended to cause producers to become a little apathetic and, if reports are to be believed, much of the keenness of the days when the plate count was solely employed is disappearing. Farmers had become interested in bacterial counts, unsatisfactory as the methods by which they were obtained might be, and as they adopted improved methods of production, they were pleased to see the bacterial content of their samples decreased. By the use of this method, it is impossible to indicate to a producer that his sample is either better or worse than the previous one, provided that both samples satisfy the test, without extending the reduction period indefinitely. It is probable, therefore, that its employment has caused the standard of designated milk production to be somewhat relaxed as a producer obtains little satisfaction from the results achieved. Indeed, a careless producer may be surprised to be told that his samples are satisfactory, when, for a variety of reasons, he knows that his methods over a period of months have been steadily deteriorating. It is also true to say that large numbers of coliform organisms might be added to very good milk without bringing it unduly under suspicion. If the estimation of coliform content were regularly carried out, this would be detected but, as the Milk (Special Designations) Order does not require this examination to be made with every sample, it is quite possible for pollution of this type to escape detection.

Some remarkably strange results have been reported where the method has been employed in conjunction with the plate count. Samples which have satisfied the test would, if the plate count had been sole criterion, have been rejected, some such samples possessing a plate count of over a million organisms per millilitre. While the test provides a speedy means of estimating the quality of milk, it would have been advisable if the plate count together with a constant estimation of coliform organisms present in a sample had remained as adjuncts to its use, particularly as these tests are necessary for assessing conditions at the point of production and for checking improvements.

As already mentioned on page 381, this test is also useful in the *assessment of pasteurised milk supplies*. The examination of such milk for total bacterial content aims mainly at detecting recontamination after treatment from inefficiently-sterilised surfaces during cooling and bottling and it should provide an estimate of the keeping quality of milk in the hands of the consumer. Although the plate count, in conjunction with the phosphatase test, is the approved method of examination of pasteurised milk samples, it can be safely stated that no known bacteriological test will properly assess efficiency of the process. The plate count has received much criticism as a means of checking the pasteurisation process as by its employment for this purpose it is not possible to obtain adequate information as to the extent of recontamination except in cases of gross errors in plant management, nor does it bear any relation to the keeping quality of the article, the majority of organisms present being thermoduric and these have little influence on the keeping quality of the article when maintained at household temperatures. The organisms which survive processing and which influence keeping quality are only present in small numbers and the aim of testing should be to assess the effect of these organisms. For this reason, the methylene-blue reductase test has received considerable attention as a means of determining the keeping quality of pasteurised milk. Research workers have found that, at 18° C., the time taken to reduce methylene blue is closely related to the keeping quality of both raw and pasteurised milks held at the same temperature. Considerable commercial importance must be attached to this test carried out at such a temperature for this purpose, as it demonstrates the length of time milk will keep after delivery to the consumer.

The period of time required for reduction has proved an obstacle to its successful employment and it has been found necessary to store samples for twenty-four hours at 18° C. in order that organisms which cause milk to sour can develop sufficiently to render their detection easy. Once the sample has been stored for the requisite period, the methylene-blue test is carried out in the usual manner. There appears to be a close relationship between the reduction time of milk and its coliform content, and it should be noted that this test bears no relation to the colony count.

The Heat-treated Milk (Prescribed Tests) Order, 1944, and the Milk (Special Designations) Regulations, 1946, specifiy that the methylene-blue test shall be applied to all heat-treated and pasteurised milks in accordance with the method set out on pages 379 and 380. Milk which fails to decolourise the dye in thirty minutes is deemed to have satisfied the requirements of the Order or Regulations. Milk to be tested must be maintained at atmospheric shade temperature from the time of sampling until examined (the temperature must not exceed 65° F.). The test must be commenced between the hours of 9 a.m. and 10 a.m. on the day after the sample was obtained.

Resazurin Test

This test has been officially adopted for grading milk under the National Milk Testing Scheme and for this reason requires consideration. For several years now, the methylene-blue test has been acknowledged as a means of testing the activities of organisms present in milk. Although a reasonably quick result was obtainable, it was necessary to discover some other means of testing which was even more speedy, and the resazurin test supplies this demand. Resazurin is more quickly reduced than is methylene blue by weak reducing systems present in milk, whether produced by bacteria or inherent in the liquid. The two tests should not, however, be regarded as competing tests. Rather are they complementary as each detects certain shortcomings in a sample of milk tested, the selection of the test depending upon the use to which the milk is to be put. The methylene-blue test is of primary importance when milk is to be consumed in its raw state as in the case of designated raw milks, while the resazurin test is more sensitive to high cell counts, which are frequently due to the presence of mastitis in herds and which indicate the presence of organisms likely to affect milk processing. For this reason, the test has been adopted, purely on a commercial basis, as a means of differentiating the suitability of milk for processing and also as an inducement for the production of cleaner milk.

It is most essential that milk should be examined immediately it is received to avoid taking into the plant an article likely to endanger the final product from the standpoint of quality. Milk may suffer from quality defects such as physical dirt or absorbed odours which do not become worse as time progresses, irrespective of the time which the liquid may be kept. There are, however, bacterial defects which may become progressively worse, thereby endangering keeping quality and rendering it quite unfit for processing. For this reason the resazurin test is extremely useful for the selection of milk from among supplies received at the depôt or collecting station.

During the test, the resazurin-milk mixture changes from a blue colour, through mauve to pink, and finally, in the case of bad samples, to white and the colour change is irreversible. The colour developed at the end of the standard test is dependent upon :

(1) Initial bacterial contamination.
(2) Amount of bacterial development during incubation period.
(3) Reducing tendencies of organisms.
(4) Abnormal characteristics of milk.

Certain *precautions as to sampling* milk to be tested in this manner require to be observed. These are :

(*a*) Samples should be taken from churns immediately on arrival at the depôt.

(*b*) Long-handled dippers (15-inch handle) of 4 ounces capacity should be used for sampling.

(*c*) Before the sample is taken, milk in the churn should be well stirred and plunged with the dipper for five seconds.

(*d*) The sample should be taken well below the surface of the milk.

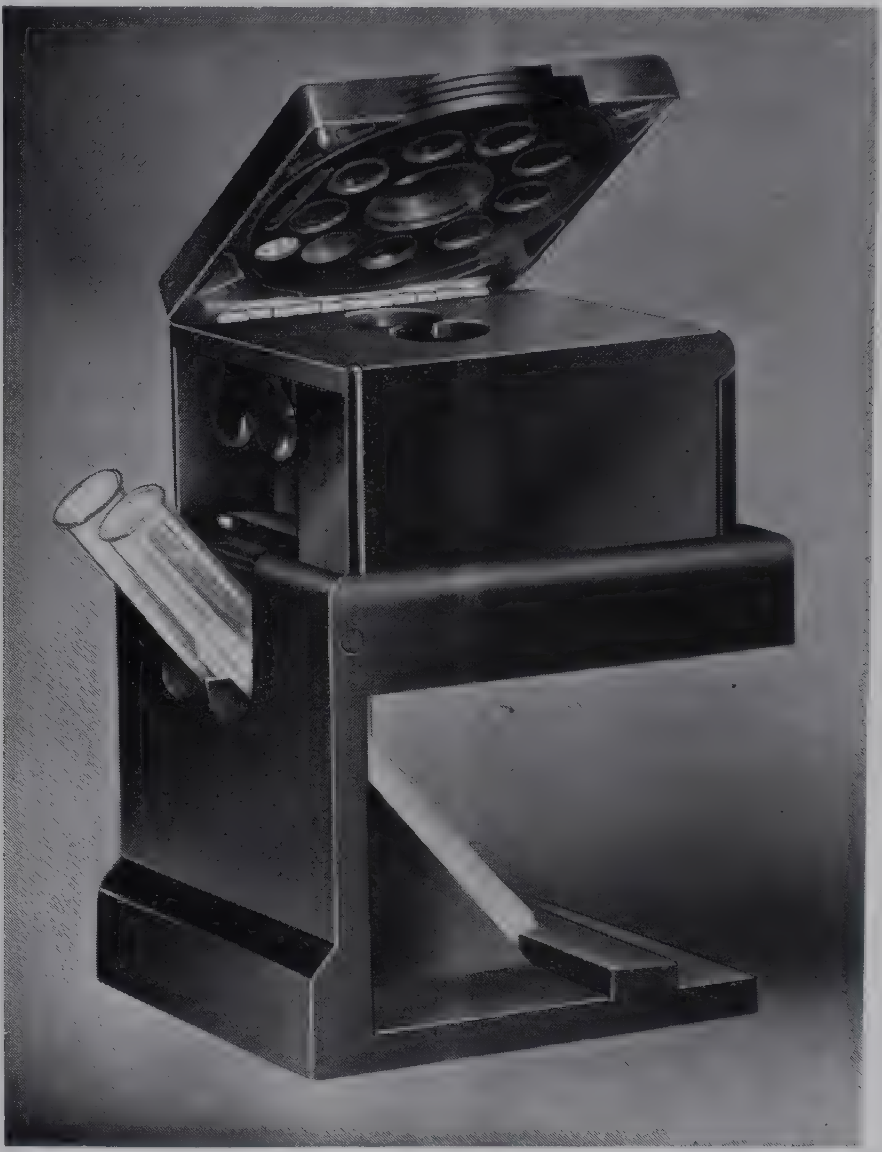
(*e*) Samples from producer-retailers and from direct consignors must be taken between point of production and delivery to the consumer.

(*f*) If the milk is in sealed bottles, one bottle should be picked at random and delivered to the laboratory unopened.

(*g*) After each sample has been obtained, the dipper should be rinsed in cold water and then sterilised in boiling water up to within 3 inches of the end of the handle for not less than thirty seconds. If a composite sample is taken from two churns from the same producer, the dipper need not be sterilised between sampling the two churns.

On arrival at the laboratory, milk should be stored in the following manner:

(1) *P.M. Milk.* Maintained at atmospheric shade temperature from time of sampling until 5 p.m. on day following production. Should then be either tested immediately or stored at 35° to 40° F. until 9 a.m. the following morning.



By courtesy of The Tintometer, Ltd.

FIG. 197. Lovibond All-Purposes Comparator.
(Used for Phosphatase and Resazurin tests.)

(2) *A.M. Milk.* Maintained at atmospheric shade temperature until 9 a.m. on day following production before testing.

(3) *Mixed A.M. and P.M. Milk.* Treated as A.M. or P.M. milk whichever is the older.

The following particulars regarding each sample should be recorded:

(*a*) Name or code number of producers or laboratory number of sample.
(*b*) Name of farm at which milk is produced.
(*c*) Time of milking (A.M., P.M., or mixed).
(*d*) Time of sampling.

A suitable book for recording particulars of the samples as obtained should bear the following headings :

(1) Laboratory sample No.
(2) Name and number of producer.
(3) Gallons of milk in churn.
(4) Time of milking.
(5) Time test commences.
(5) Result of test (ten-minutes or standard).
(7) Remarks.
(8) Action taken.
(9) Name of person making test.

The *apparatus* required consists of :

(1) An All-Purposes Lovibond Comparator shown in Fig. 197. This is fitted on a special stand and the same apparatus can be used for the phosphatase test if desired.

(2) The Resazurin disc. This contains seven empirical colour-glass standards which range from blue, through mauve and purple to pink and finally colourless.

(3) A water-bath thermostatically controlled to maintain a temperature of 37° C. This is similar to that employed for the methylene-blue test and is described on page 379 (Fig. 196).

(4) Test tubes graduated at the 10-millilitre mark and a 1-millilitre pipette. All tubes should be made of glass with a standardised thickness and should be of similar colour.

(5) Resazurin solution. This may be prepared from stock solution or from standardised resazurin tablets. The solution used for testing is made up by diluting 0·05 per cent. stock solution with 10 volumes of sterile, glass-distilled water to make the 0·005 per cent. bench solution, or by dissolving one standardised tablet in 50 millilitres of sterile, glass-distilled water. Stock solution should at all times be kept in a refrigerator.

The *standard resazurin test* is more exacting of the two and the result is more reliable. A test-tube is filled with 10 millilitres of well-mixed and aerated milk to the graduated mark with aseptic precautions, the mouth of the test-tube and of the sample bottle being flamed. One millilitre of resazurin solution (0·005 per cent.) is added and the tube sealed by means of a sterile rubber stopper. The tube is then inverted twice after which it is placed in a water-bath maintained at 37° C. for one hour. At the expiration of this period, the tube is removed, inverted once or twice, wiped and placed in the right-hand slot of the comparator so that it rests in the ramp as illustrated and comes below the colourless centre of the disc. The comparator should face a north window or towards a white wall or surface and should be placed at a height which will enable the operator, when standing above it, to look down directly on to the two apertures. A tube containing a similar amount of the same coloured milk, without resazurin, is placed in the left-hand slot to act as a background for the colour-glass standards. When highly-coloured milks are to be tested, similar to those obtained from Channel Islands cattle, care must be taken that the milk in the "blank" tube possesses the same depth of colour. The variable and inherent colour of milk is thus compensated for in the reading. The disc is now revolved until the sample is matched, or its colour falls between two standards and the reading noted. Samples should be matched on tint and not on intensity of colour. If the colour fall about half-way between two numbers, half the value should be recorded. It is extremely rare that accurate matching is impossible. If milk in the tube is white or possesses a shallow pink band on its upper surface, 0 should be recorded, while if the liquid exhibits a mottled, streaky whitish-pink or very pale pink colour, ½ is recorded. If the samples are examined by normal electric light, results will be approximately one figure too high. For this reason some form of daylight lighting or a Lovibond lamp unit should be used. This consists of a fused, two-compartment glass cell which is placed in a holder in front of the observation apertures of the comparator. The two compartments are filled with blue and pink solutions of internationally-standardised C.I.E. formula and this corrects yellow artificial light to a very close approximation of north daylight. A 60-watt pearl lamp with a bakelite shade provides the illuminant and tests have shown that results obtained with this apparatus agree extremely well with those obtained by daylight.

The results of the tests are interpreted as shown in Table 19.

TABLE 19

Colour Glass No.	Quality.	Colour.	Procedure.	Category.
6	Excellent	Blue	Accepted for liquid milk market.	A
5	Very good	Slightly mauve		
4	Good	Mauve		
3	Fair	Pink-mauve	Readings between 3½ and 1 (both inclusive)—salvaged if possible, otherwise rejected.	B
2	Poor	Pink		
1	Bad	Deep pink		
0	Very bad	White.	Readings of ½ and 0. Rejected—to be returned to producer.	C

The assessments include both bacterial quality and freedom from any abnormality in a pathological sense. Results of the tests are notified by the Advisory Dairy Bacteriologist to the producers concerned. All unsatisfactory results are dealt with by County Milk Advisory staff who visit all farms concerned with a view to ascertaining where production methods have gone astray. The unsatisfactory results should also be notified to the local Sanitary Authority for the district, whose Sanitary Inspector should visit the premises with the County Advisory Officer. It is to be regretted that the Central Advisory Committee which was constituted to handle the technical details of the scheme has now seen fit to decide against this policy unless such sanitary inspectors are undertaking advisory work at the request of War Agricultural Executive Committees.

The *ten-minute platform rejection test* requires a similar technique to that set out for the standard test except that tubes containing the samples are retained at a temperature of 37° C. for ten minutes only. As this is a short-time test, timing must be extremely accurate. If the colour shown at the end of the test is less than that indicated by disc reading 4, the milk is of poor quality. If the colour changes to mottled pink or colourless (disc reading ½ or 0), a very low quality is indicated. Such milk should be salvaged if possible but otherwise may be returned to the producer, the final decision depending on facilities for utilisation which are available.

Unsatisfactory results may be due to some cause which is quite unrealised by producers and they should not be accused of faulty production methods as a result of a single test. It is recommended that three tests should prove unsatisfactory before any restrictive action is taken. All supplies giving results below standard 3 should be further examined by a direct microscopic test, a smear being made from the milk in the offending tube which is fixed and stained with methylene blue (see page 374). Large numbers of bacteria indicate careless methods of production while the evidence of leucocytes demonstrates the presence of mastitis, particularly if these are accompanied by long-chained streptococci. It should be noted that a decrease in intensity of the original blue colour is correlated with a high fat content and should not be taken as an indication of poor quality.

Certain precautions require to be observed when these tests are made, as follows :

(1) After the resazurin has been added to 10 tubes, they should be sealed and placed in the water-bath before any more tubes are set up.
(2) Disc glasses should be free from dust and moisture.
(3) It is important that both tubes should be equally illuminated and free from shadows.
(4) The pipette used for transference of the dye solution to the tubes of milk should *not* be introduced into the stock solution.
(5) The bench solution (0·005 per cent.) must be freshly prepared for each day's work.
(6) Dye solution and milk must not be exposed to direct sunlight.
(7) The interior of the water-bath must be kept dark and the level of the water should be maintained above the level of the milk in the tubes.
(8) Temperature of the water-bath must be checked at half-hourly intervals.
(9) Thermometers on water-baths should be checked monthly against a standard thermometer.
(10) Water-baths should be cleaned out at weekly intervals, fresh water being added.
(11) Persons carrying out the test should possess normal colour perception.

The *advantages* of this test have been summarised by Davis as follows :

(*a*) A speedy result is provided.
(*b*) An accurate estimation of colour can be obtained.
(*c*) One reading only is required.
(*d*) Air does not affect reduction.
(*e*) Mastitis may be easily detected.
(*f*) It is sensitive to organisms of weak reducing power and to reducing influences of abnormal milks.
(*g*) Owing to the speedy results obtainable, contamination in sampling and making the test are not so important as is normally the case.
(*h*) If complete reduction of the resazurin dye is effected, all information to be obtained from the methylene blue test is provided.

The results to be obtained from the employment of this test are decidedly encouraging and there is no doubt that a considerable improvement in the cleanliness of the national milk supply will result, always provided that these results obtained are utilised in every case by the Advisory Officers concerned *and* by Local Authorities, for the elimination of faulty methods.

It has already been mentioned that the methylene-blue reductase test can be employed in *assessing efficiency of the pasteurisation process* and the resazurin test can be utilised for a similar purpose. Samples from bottles of pasteurised milk or line samples taken at various points in the plant should be obtained, and after the liquid has been placed in the test-tubes these should be incubated at 18° C. for twenty-four hours. At the expiration of this period, tests are carried out in the manner already described except that samples remain in the water-bath for three hours, disc readings on the comparator being obtained at half-hourly intervals. If at the end of one and a half hours, the disc reading is less than 4, such samples should be classed as unsatisfactory on account of contamination from unsterile surfaces, whilst if the reading is ½ or 0 for the same period of incubation, this is an indication of gross contamination. Any marked changes in line samples taken from the plant indicate some fault between two particular points and an investigation should be made. Normally, with satisfactory treatment, no change should be evidenced at the end of three hours' incubation.

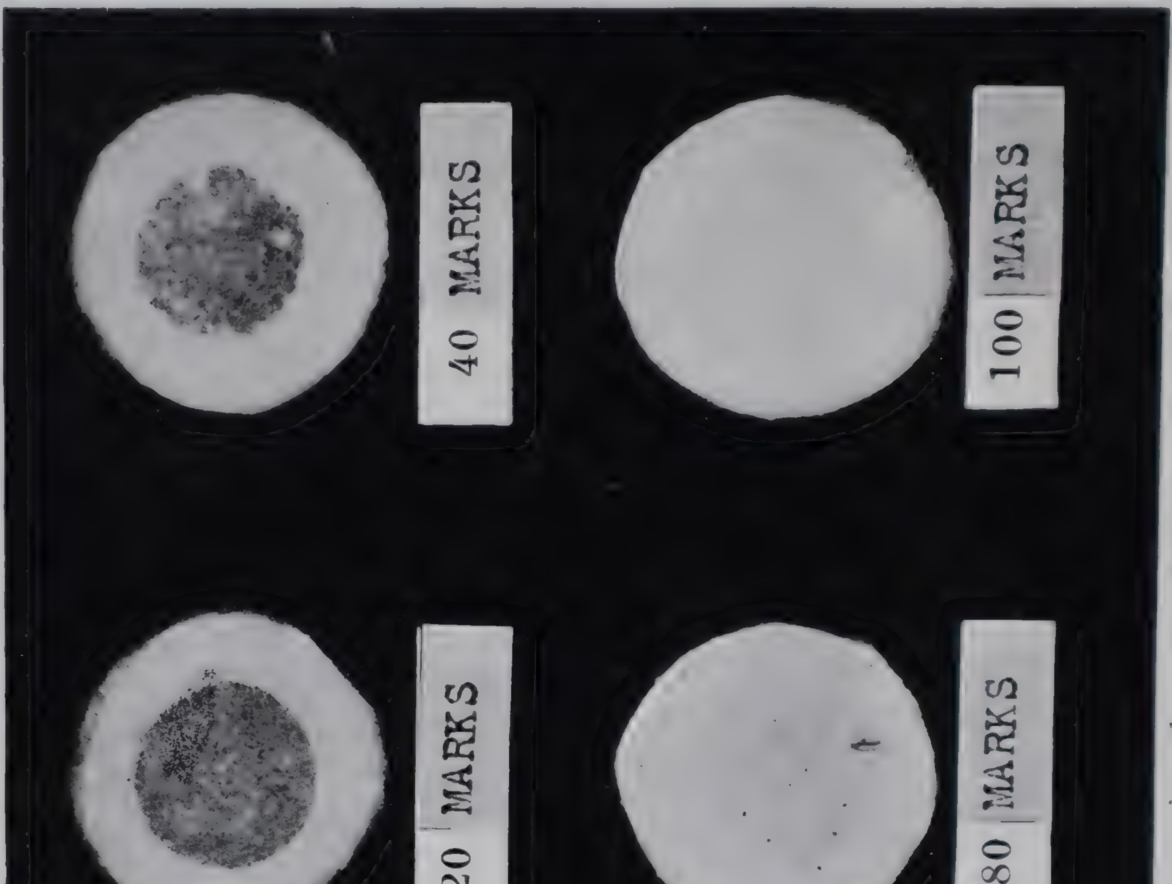


Fig. 198. Sediment Pads showing comparisons between relative amounts of sediments in different batches of milk.

Reproduced by permission of the Controller of His Majesty's Stationery Office from the "Guide to the Conduct of Clean Milk Competitions"—Ministry of Agriculture and Fisheries, Bulletin No. 46, 1934.

The normal method for *testing the sterility of churns* by means of rinsing is outlined on page 371, but Davis and Watson have adapted the resazurin test to serve a similar purpose. For this test, 1 millilitre of rinse is inoculated into 10 millilitres of sterile separated milk and incubated at 22° C. for twenty-four hours. At the end of this period the test is carried out at a temperature of 37° C. in the manner set out above. Any sample which gives a disc reading of 5 or less after thirty minutes' incubation should be regarded as unsatisfactory.

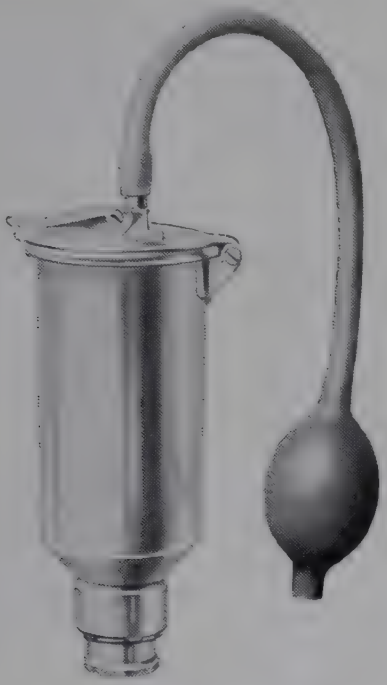
Other Testing Methods

Apart from bacteriological examinations of milk supplies, a variety of tests exist which indicate the condition of milk as regards cleanliness. Some of these tests may be easily applied by producers or distributors to their milk. Such are :

(1) Sediment Test.
(2) Acidity Test.
(3) Keeping-quality Test.

It must be remembered, however, that, while the above tests are extremely simple in application and are definitely of value, they cannot be regarded as entirely reliable.

(1) **Sediment Test.** This test is easily applied and enables the person operating the testing apparatus to detect the presence of sediment in milk. It is particularly useful to public health officers, as it can be applied at the farm or in the dairy of the distributor, while results may be quickly demonstrated to the person concerned. Comparisons may thus be made between relative amounts of sediment in different batches of milk, as shown in Fig. 198. The test is especially useful in educating producers as to the need for cleanliness, while it can also be used by them in turn to educate milkers as to the necessity for increasing care in methods. Many producers and milkers readily understand visible dirt, whereas they find it difficult to grasp the presence of any bacterial content. Needless to say, these tests should always be carried out before milk is strained.



By courtesy of Sutherland Thomson & Co.
FIG. 199. "Minit" Sediment Tester.

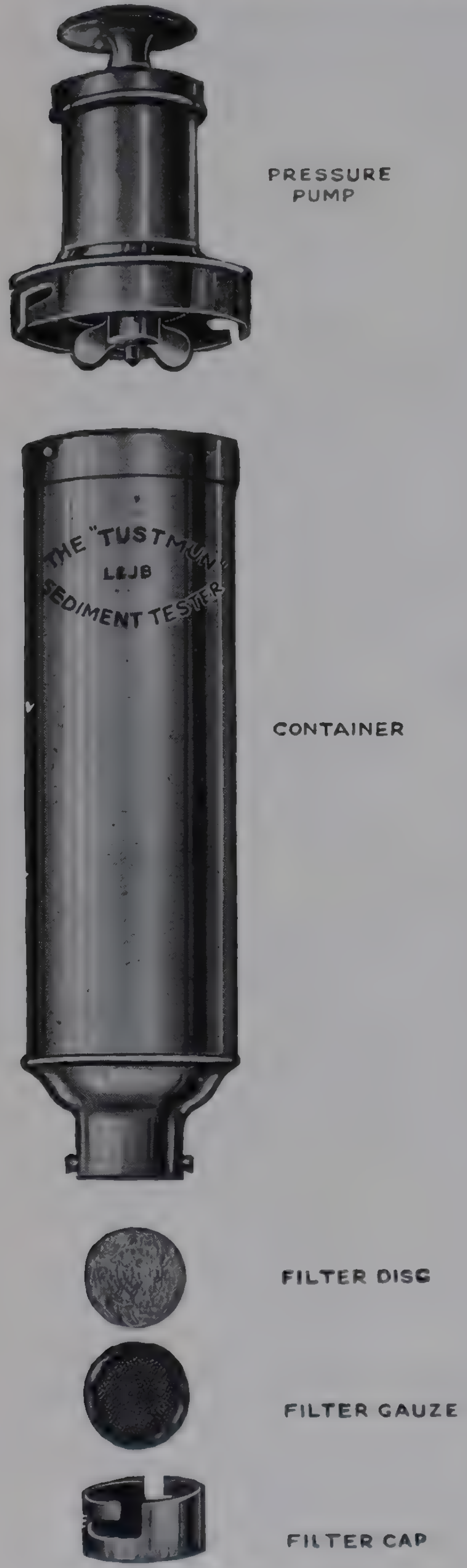
The advantages of this test may be described briefly as follows :

(1) For research work in order to determine the actual amount of sediment in a given quantity of milk or as a means of judging efficiency of straining or clarification processes.

(2) As an object lesson to a careless producer.

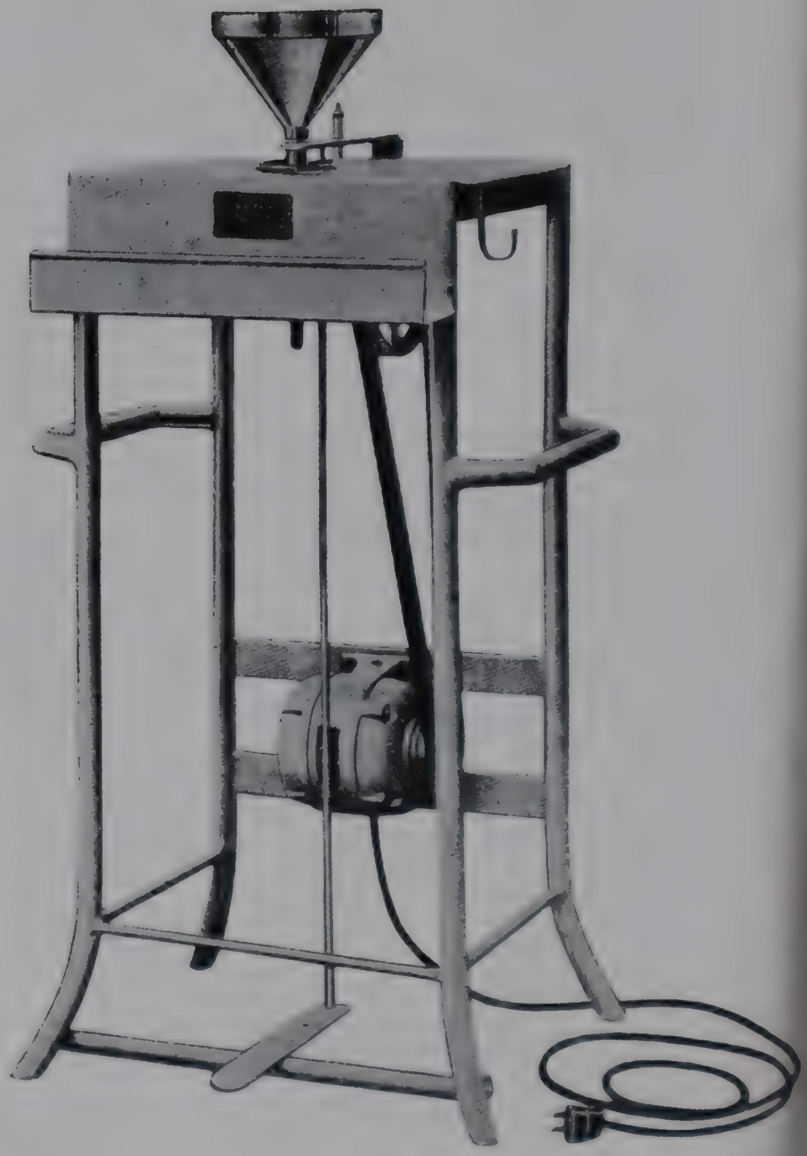
(3) As a general check on incoming milk at a collecting station or processing depot.

The two types of sediment tester in general use are the *Minit* and the *Tustmun*. Both types consist of a metal cylinder holding either a half-pint or a pint of milk. Milk is forced through a cotton-wool disc by pumping. This disc is fixed in the bottom of the cylinder with the rough or woolly side upwards. After the milk has been pumped through, the pad is removed and the result compared with a standard series of pads. Discs are roughly the size of a penny, and if milk does not readily pass through, it should be warmed.



By courtesy of Llewellins and James, Ltd.

FIG. 200. "Tustmun" Milk Sediment Tester. (Open).



By courtesy of Sutherland Thomson & Co.

FIG. 201. "Van Doorn" Laboratory Sediment Tester. (Electrically driven).

A simple form of tester which may be used in the laboratory, consists of a bottomless bottle similar in shape to a sterilised milk container but with a larger diameter neck. This is fixed in an inverted position in a stand, and the cotton-wool pad is clamped to the neck. A measured quantity of milk is then poured in. Milk either flows or is pumped through the pad, leaving any sediment behind. The pad is compared with a standard series of pads as before.

After use, all pads should be dried, treated with formalin solution, and finally mounted on a card or in an album for future reference.

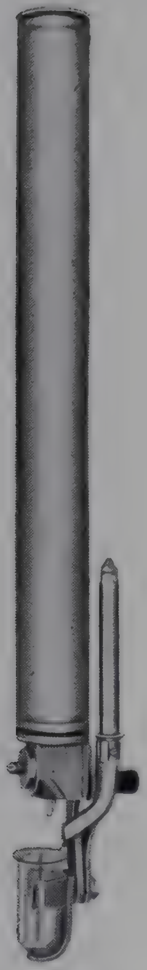
The *Van Doorn Sediment Tester* is a more ambitious piece of apparatus designed for use at collecting stations and large dairies, on milk receiving platforms. Milk to be tested is automatically drawn from the container, measured in a glass cylinder to the required volume and automatically drained. Vacuum pumping is provided, milk being passed through a filter card which can be filed for future reference. Where a large number of supplies are received daily, this apparatus, shown in Fig. 201, is a useful adjunct to a laboratory. Each test can be made in ten seconds and the apparatus is easily cleansed.

The volume of sediment in milk may be measured scientifically by the following method. A centrifuge tube, the tapering end (holding 0·050 millilitre of liquid) of which is graduated with sub-divisions of 0·002 millilitre, the lowest graduation being 0·004 millilitre, is used. Two hundred millilitres of well-mixed milk to be tested are placed in a sedimentation vessel and 0·2 millilitre of 40 per cent. formaldehyde solution in 10 millilitres of water is added for each 100 millilitres of milk. The milk is allowed to stand for seventy-two hours, being stirred at frequent intervals in order to dislodge the cream layer and to allow any dirt to settle to the base of the vessel. At the end of this period the milk is carefully transferred to one or two centrifuge tubes, according to the quantity to be examined, care being taken to ensure that every vestige of milk *and* sediment are transferred to the tubes and that none is lost. After a further forty-eight hours' sedimentation, the tubes are transferred to a centrifuge, being sealed with rubber caps, and the machine is spun for three minutes at 2,000 revolutions per minute. On removal, the milk is carefully drawn off from the tubes in order that the sediment is not disturbed. Frequent washings are given with water to remove soluble milk solids, ammonia solution, more water, hydrochloric acid and, finally, further washing with water so that the sediment is thoroughly cleansed. When the final washing water has been carefully removed, the dirt remains in a compact mass at the bottom of the tube and the reading is taken. The result is expressed as parts by volume of moist dirt in 100,000 parts by volume of milk. The Report of the Sub-Committee of the Analytical Methods Committee of the Society of Public Analysts have stated in regard to this test :

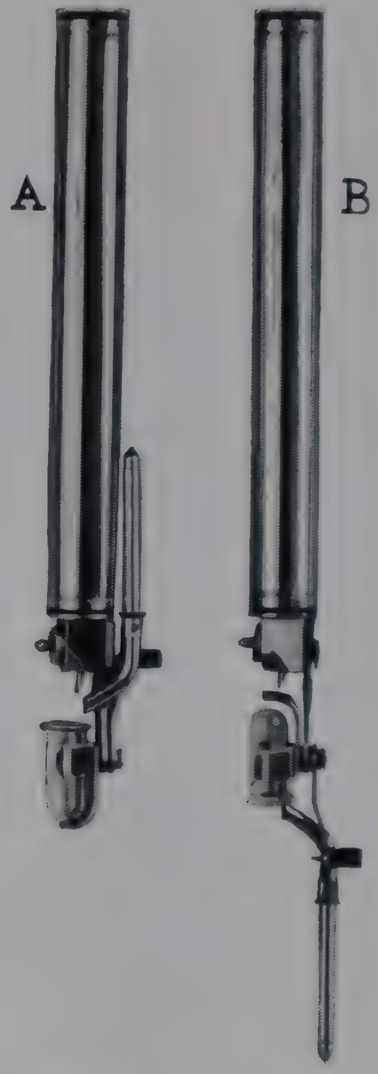
> "It is not desirable to recommend legal action in the case of an isolated sample of dirty milk unless the amount of moist sediment determined by the above method exceeds 3 parts by volume in 100,000 parts of the sample."

(2) **Acidity Tests.** These tests are based upon the assumption that all acid produced in milk is lactic acid. The percentage of acidity is calculated by using an alkaline solution of known strength to neutralise lactic acid in a given quantity of milk. If milk is stored at ordinary temperatures, acidity gradually develops owing to the multiplication of lactic-acid organisms. A point is finally reached at which this acidity is sufficient to

curdle milk owing to precipitation of casein. Phenolphthalein is used as an indicator. This is colourless in an acid solution, becoming red in the presence of an alkali. Ten millilitres of milk are placed in a dish and 1 millilitre of indicator is added. A standard solution of deci-normal caustic soda is run into the milk from a burette. The addition of caustic soda solution to the milk is carried out very slowly, the mixture being continually stirred until the pink tint of the indicator persists. The milk is then neutral in reaction. The readings of the burette before and after caustic soda is run out give the amount of solution required to obtain the necessary reaction. Each millilitre of alkali used is taken to denote 1° or 0·1 per cent. of acidity.



By courtesy of Hiron and Rempler, Ltd.
FIG. 202. "Bodo" Milk Tester.



By courtesy of Hiron and Rempler, Ltd.
FIG. 203. "Bodo" Milk Tester.

Thus, if milk needs 1·5 millilitre of alkali to obtain the required reaction, the milk would possess an acidity of 1·5° or 0·15 per cent. The standard limit of acidity usually recognised is 2° or 0·2 per cent. From a bacteriological standpoint, this test is crude, although some relationship exists between degree of acidity and number of bacteria in milk. The test possesses the advantages of convenience and rapidity in use.

There are several proprietary makes of acidity-testing apparatus on the market. The usual type consists of several corked test-tubes marked in two positions. Milk is poured into the tube until it reaches the first or lower mark. A liquid indicator is next poured in until the level of the mixture reaches the second mark. The tube is finally stoppered, well shaken, and the colour read. The colour indications are:

Pink coloration denotes good, sweet milk.
Light brown colour denotes slightly sour milk.
Yellow colour denotes sour milk.

If the percentage of acidity present exceeds 0·2, the sample will immediately curdle.

The "*Bodo*" *Acidity Tester* is a useful piece of proprietary apparatus consisting of the following parts :

(*a*) Alcohol container, with filling cap.
(*b*) Measure and dipper.
(*c*) Cock with drilled opening of 2 ml.
(*d*) Dipping tube.
(*e*) Holder for reaction tube.

The apparatus is manipulated by unscrewing the cap and filling the alcohol container with either methyl alcohol (CH_3OH), 70 per cent., or ordinary methylated spirit, 70 per cent. alcohol content. The apparatus is held in the left hand in the position shown in B (Fig. 203), and the dipping tube is inserted in the churn. The filling tube is then raised as shown at A, when milk flows into the glass, 2 per cent. of alcohol or spirit flowing with it. It is then gently shaken and, if the acidity of the milk is high, the mixture becomes flaky. This test can be made by a non-technical person in a few seconds.

(3) **Keeping-quality Tests.** Estimation of keeping quality of milk is often made to supplement examination for bacterial content. Milk to be tested is placed in a 4-oz. Kali bottle provided with a glass cover, the cover and bottle having been previously sterilised. It is maintained at 60° F., which is regarded as an average yearly temperature, being tasted at intervals. Each time tasting occurs, a portion of the milk is placed in a test-tube and immersed in boiling water for five minutes. Odour is then noted and milk examined for clotting. The signs used for recording the results are :

— = Sweet.
. = Doubtful.
T = Slight taint, but insufficient to render the milk unfit for use.
X = Condemned on taste—distinctly tainted.
+ = Clots on boiling before a taint is recorded.
* = Condemned on taste and clots on boiling.
C = Clotting of the sample in the test bottle.

Clean milk should keep for three or four days at a temperature of 60° F.

Laboratory Facilities

In a previous chapter, a list of centres where examination of milk samples may be carried out has been supplied. In addition to these centres, there are many excellent privately-owned laboratories which perform this work. A large number of Local Authorities who carry out routine sampling send their samples to these laboratories, while others, mostly the large towns, possess their own premises equipped with special staffs to carry out the necessary examinations. Whichever method is used, it is advisable that the laboratory should be situated adjacent to the district concerned, in order to prevent any delay in transmitting samples.

The cost of providing a laboratory service is fairly high but a great saving in examination fees will ensue. Properly equipped laboratories are very desirable, but for routine milk examinations other than biological tests for the presence of tubercle bacilli much simpler equipment can be provided with complete success. This being so, it would appear highly desirable that every Council should provide its own laboratory and not rely on testing being carried out by outside bodies as so often is the case. Two or more Authorities might join in the provision of a small, centrally situated laboratory to their mutual benefit.

CHEMICAL EXAMINATION OF MILK

The chemical examination of milk is important, both as an integral part of any milk-control scheme and also as a corollary to bacteriological analysis, upon which it may act to a certain extent as a check. There are no historical records which will give a guide to fixing a date or naming a period when the adulteration of milk first became a practical problem. It is probable, however, that there were plentiful supplies in the world for a considerable period and possibly, in those days, no great inducement existed to increase quantity by artificial means. Indeed, it is probable that the adulteration of milk by addition of water or by abstraction of butter-fat is one of the so-called " blessings " which follow in the wake of civilisation. Milk may be chemically tested either in the laboratory or by the producer or dairyman in a variety of ways, as follows :

(1) Specific Gravity.
(2) Fat Percentage Estimation.
(3) Total Solids and Water.
(4) Non-fatty Solids.
(5) Added Water.
(6) Tests for Heated Milk.
(7) Refractive Index.

It is important to remember that the Sale of Milk Regulations, 1939, provides that a sample of milk containing less than 3 per cent. of fat or less than 8·5 per cent. of other solids is to be presumed, for the purpose of the Food and Drugs Act, 1938, not to be genuine until the contrary is proved.

This limit for fat is exceedingly low when modern scientific principles of farming are considered as the average fat content of milk from a mixed herd rarely falls below 3·5 per cent. Milk of individual animals, however, frequently fails to reach the standard fixed, this discrepancy being very noticeable amongst pedigree animals from which it might be expected that milk would be of the highest obtainable standard. Because of these variations and to prevent injustice, provision has been made for " appeal to the cow " samples to be taken when necessary. Should such samples fall below the specified standard, an appeal may be allowed. This option of appealing to the cow appears to be rather ridiculous in times such as these. It is to be regretted that it is still legal to sell milk of any composition so long as the producer is able to prove it is in the same condition as when it came from the cow. This has led to a growing evil, which is practised with impunity by some dairy farmers, of breeding for yield irrespective of quality or of selling the bulk of their milk without the " strippings," these being fed to calves who naturally thrive on the butter-fat.

It is now time that some radical alteration was made in the present standard for milk-fat and for solids-other-than-fat. The public pay for and expect to obtain milk which attains to a decent nutritive standard, but the producer is apparently under no legal obligation to provide this. There is no doubt that milk from a properly managed herd would reach the present standard at all times. A higher compulsory standard for butter-fat and for solids-other-than-fat is an urgent necessity and producers should be required to maintain such standard. This would prevent the present unsatisfactory position and ensure that the public would get the article for which it pays. No one can protest that a higher standard is impossible of attainment when it is realised that milk-fat percentage may be as low as 1·5 per cent. or as high as 10 per cent., according to the portion of milking concerned. While milk containing this low percentage is seriously deficient in one of its main constituents, that which contains 9 to 10 per cent. of fat is rather out of place, particularly for feeding of infants upon whom such a high fat content would give rise to undesirable digestive disturbances.

Many of our colonies and some foreign countries have fixed a standard for butter-fat content of milk which is higher than that at present in force in this country. It may be argued that to fix a higher standard savours of intimidation but it is not a question of such action. Rather it is a question of putting forth a policy of education backed by legislation which it is necessary to pursue in order that the consuming public may be assured of a wholesome milk supply.

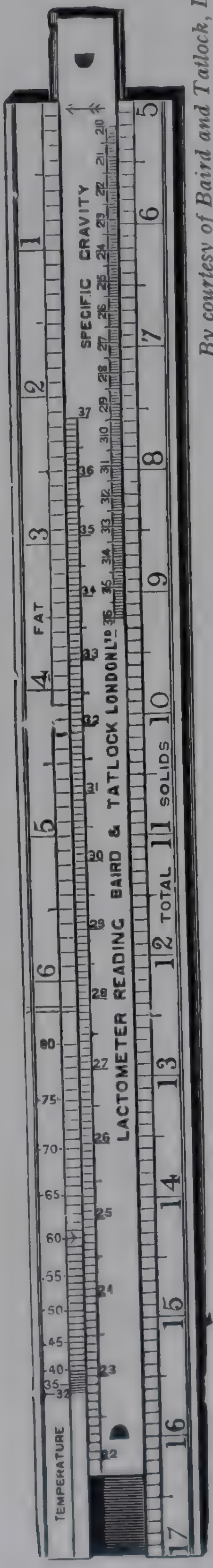
(1) **Specific Gravity.** An average milk possesses a specific gravity of 1·035, but may vary between 1·027 and 1·039, and within limits this specific gravity supplies a rough indication as to the composition of milk. Specific gravity is determined by means of a *Sprengel Tube*, a *Westphal Balance* or by a *Lactometer*. Although the Sprengel Tube or Westphal Balance are more accurate and are employed in the large analytical laboratories, the lactometer is in more general use. The latter possesses certain advantages to producers particularly if used in conjunction with the Gerber test. These are as follows :

(1) It affords an easy method of estimating the value of a milking cow. By taking into consideration the quality as well as quantity of milk, the merits of a particular animal may be determined.

(2) It affords a simple means of assisting in the estimation of the effects of particular varieties of food-stuffs on milk produced by the herd.

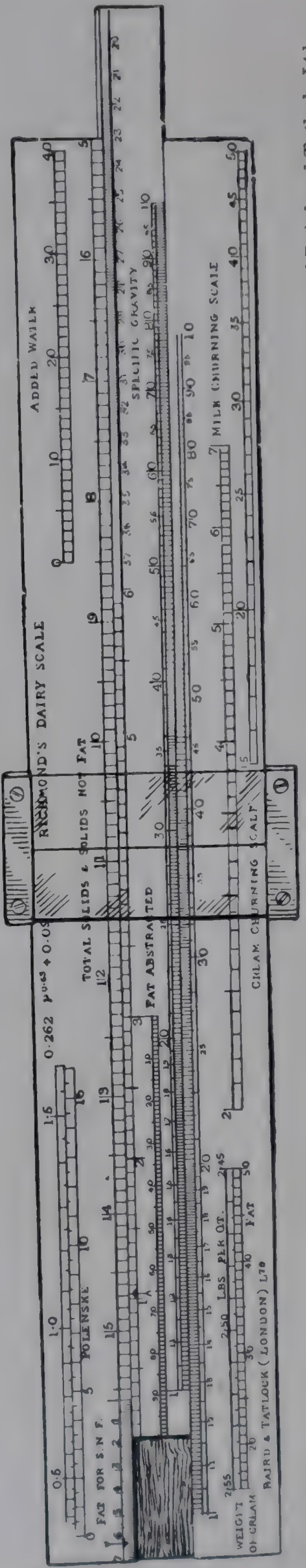
(3) It assists in determining the value of particular pastures.

The lactometer is a glass instrument with a weighted bulb and stem, a scale being marked on the latter portion of the instrument. It is actually a hydrometer suitably scaled, and operates on the same principle, i.e. the law of displacement. The scale is marked from 0 downwards to either 40 or 50, the 0 representing 1,000, which is the specific gravity of pure distilled water at 60° F. Milk is heavier than water, and the better the milk is in quality the heavier it should be. To obtain the specific gravity of milk, a cylindrical jar is filled to within 2 inches of the brim and the lactometer allowed to fall slowly into the liquid. The instrument is immersed to the mark 0 by a slight pressure of the finger, after which it is allowed to rise and settle at will. The jar should be slightly wider and deeper than the lactometer. This instrument, after immersion in the manner described, will remain stationary and, at the point where the stem clears the surface of the liquid, milk will cling round it. It is customary to allow for the rise of milk by capillary attraction at this point, the usual allowance being $\frac{1}{2}$°. If the lowest figure clearly showing on the scale is 31°, the proper reading after correction would thus be 31·5°. The average specific gravity of milk is calculated at a temperature of 60° F., and, if the temperature is higher or lower than this, the reading will be affected. The temperature of milk must therefore be ascertained, this being obtained by means of a thermometer well stirred in the liquid. It will be found in practice that the temperature of milk is very seldom exactly 60° F., and it is therefore necessary to make


SPECIFIC GRAVITY
FAT
LACTOMETER READING BAIRD & TATLOCK LONDON LTD
TOTAL SOLIDS
TEMPERATURE

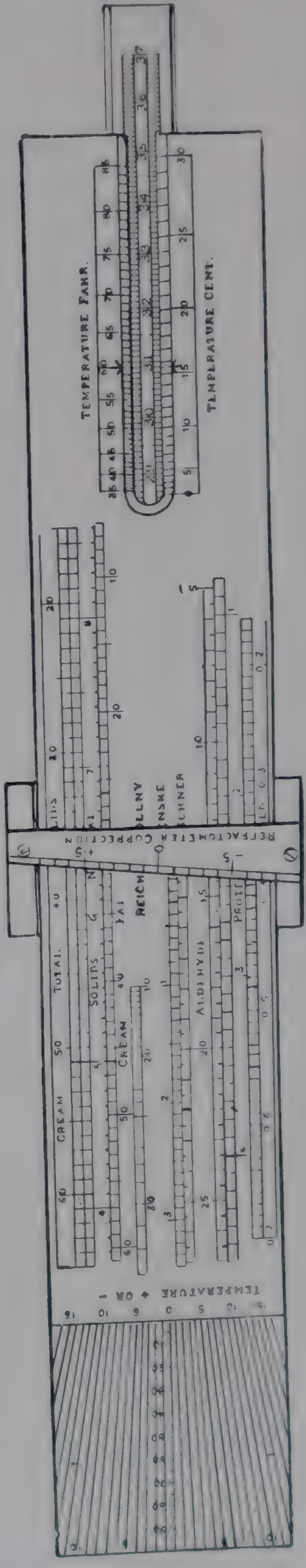
By courtesy of Baird and Tatlock, Ltd.

FIG. 204. "Richmond" Scale Rule.


ADDED WATER
RICHMOND'S DAIRY SCALE
TOTAL SOLIDS & SOLIDS NOT FAT
SPECIFIC GRAVITY
FAT ABSTRACTED
MILK CHURNING SCALE
CREAM CHURNING SCALE
POLENSKE
FAT FOR S.N.F.
LBS PER QT.
FAT
WEIGHT OF CREAM
BAIRD & TATLOCK (LONDON) LTD

By courtesy of Baird and Tatlock, Ltd.

FIG. 205. "Richmond" Slide Rule (Front).


TEMPERATURE FAHR.
TEMPERATURE CENT.
REFRACTOMETER CORRECTION
CREAM
TOTAL
SOLIDS
FAT
CREAM
REICHERT
POLENSKE
KIRCHNER
ALDEHYDE
PROTEIN
TEMPERATURE + OR −

By courtesy of Baird and Tatlock, Ltd.

FIG. 206. "Richmond" Slide Rule (Back).

a correction in the reading. It is usual in practice to make an allowance of 1° of specific gravity for every 5° deviation in temperature from 60° F. If the temperature is above 60° F. the allowance should be added to the actual reading, while, if the temperature is below 60° F., the allowance should be deducted. Milks rich in fat as compared with normal milk give a lower lactometer reading, while milks richer in non-fatty solids yield corresponding high results.

Milk which is frothing gives an untrue reading, as air bubbles lead to artificial lightness. It is also essential that milk should be well stirred before specific gravity is obtained. Lactometers of good quality should always be used, cheap apparatus being always unreliable. The instrument should be maintained in clean condition, and be tested occasionally with pure distilled water at a temperature of 60° F.

The *Richmond Scale* (Fig. 204), which is based on Droop Richmond's formula, may be profitably used in connection with the lactometer. This scale is as follows :

$$T = 0{\cdot}25\,G + 1{\cdot}2\,F + 0{\cdot}14$$

where T = Percentage of total solids.
G = Lactometer reading in degrees (corrected to 60° F.).
F = Percentage of butter fat.

The percentage of non-fatty solids is readily calculated from the formula. The modern form of Richmond Scale indicates the temperature correction of the specific gravity of milk and the total solids corresponding to known lactometer and fat values. The scale is sufficiently accurate for all ordinary purposes, and is used in conjunction with the lactometer in the Gerber test for fat percentage. On the scale, fat is graded from 0·1 per cent. to 6 per cent., the divisions being clearly marked. The fat percentage may be calculated to two decimal places. A small scale on the slide-rule adjusts itself to a temperature scale on the main piece, and the correction of the apparent lactometer reading with temperature can be exactly made. If the sliding piece is set to the known figure, the result is immediately and plainly visible. An improved form of scale for the estimation of total solids is shown in Figs. 205 and 206.

A new formula to operate with density hydrometers has been devised and a suitably modified form of Richmond's scale has now been placed on the market. The formula is :

$$T = 0{\cdot}25\,D + 1{\cdot}21\,F + 0{\cdot}66.$$

This formula is on lines comparable to that set out above except that D = density of the liquid, as indicated by the density hydrometer.

The " Collins " Milk Scale was devised by S. H. Collins, M.Sc., to simplify procedure attendant upon the use of the " Richmond " Scale. With this slide rule it is only necessary to set the reading given by the lactometer opposite the temperature at which specific gravity is taken when the percentage of solids-not-fat will at once be found opposite percentage of fat. The data needed are :

(1) Temperature of the Milk.
(2) Specific Gravity.
(3) Percentage of Butter Fat.

(2) **Fat Percentage.** The determination of the percentage of butter fat contained in milk is one of the most commonly required tests. This percentage may be arrived at in various ways, some simple and some complicated. The simplest method is that which makes use of the *creamometer*. This is a cylindrical glass jar, graduated in 10 ml. divisions and minor subdivisions up to 100 ml. but having a slightly larger capacity. One hundred

millilitres of milk are placed in the jar and remain overnight to allow cream to rise. The volume percentage, which in average milk is small (approximately 9 ml.), is then read off. As ordinary cream contains approximately one-third of its weight of fat, one-third of the volume of cream will supply a rough estimate as to percentage of fat present.

Another method of fat determination is by the use of a *Leffman-Beam Bottle.* Fifteen millilitres of milk are placed in the bottle, and to this are added 3 ml. of an equal mixture of hydrochloric acid and amyl alcohol. The mixture is well shaken and allowed to stand for five minutes. Nine millilitres of concentrated sulphuric acid are then slowly added and the whole mixed carefully with a swirling motion. While it is necessary to add sulphuric acid slowly, the speed should be sufficient to maintain a high temperature in the mixture, the colour of which changes to deep purple-brown and then gradually clears. If the mixture has not cleared after the addition of sulphuric acid, the bottle with its contents is heated in a water bath until clarification takes place. The bottle is then filled with *hot* 50 per cent. sulphuric acid to the upper level of the graduations which are to be found on the neck of the bottle. The mixture should next receive a primary spinning with the hands, after which it is finally centrifuged for three minutes at 1,200 revolutions per minute. The fat percentage is read off while the material is still liquid, the result obtained being divided by ten to give corrected fat percentage.

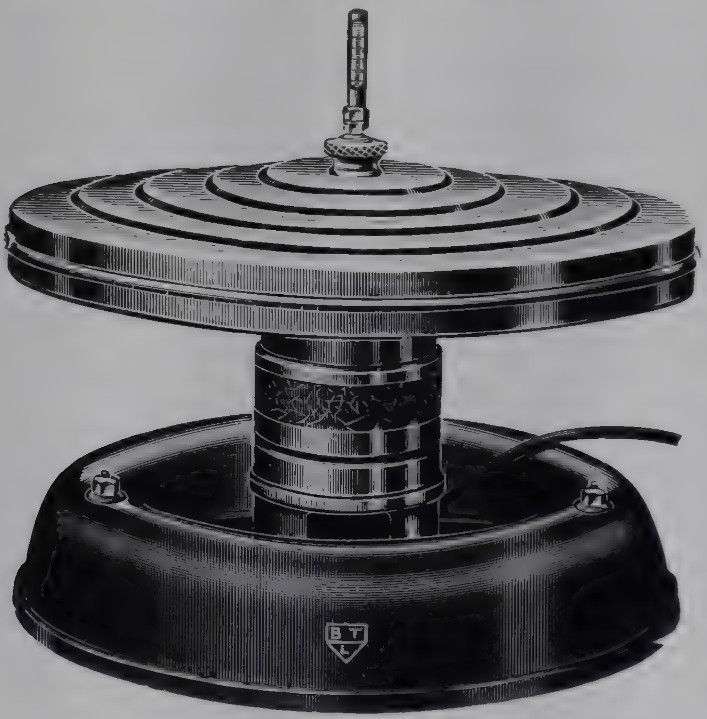

By courtesy of Baird & Tatlock, Ltd.

FIG. 207. Gerber Centrifuge (Electrically-driven).

The commonest method of estimating fat content of milk is the *Gerber* method which has been standardised and is extremely simple. It is cheap and speedy and affords the responsible official a ready means of estimating the qualities of the various milk supplies of the district. By the action of centrifugal force it is possible to separate compound fluids and to estimate their various constituents. The Gerber method renders such separation more complete, casein in suspension being dissolved by the sulphuric acid used, while the fat is clarified by amyl alcohol. The alcohol also assists fat to pass through the aqueous milk serum more easily by reducing surface tension. There are many machines to be obtained, some large enough for extensive dairies and driven by mechanical means (see Fig. 207): others small enough to hold only two tubes, such types being driven by hand. The principle of all the types is a quick rotary movement by a system of geared wheels. The special Gerber tube supplied by the makers is used, and is fitted with a rubber stopper. Eleven millilitres of milk are run into the tube, followed by 1 ml. of amyl alcohol and 10 ml. of sulphuric acid (specific gravity 1·82). Sulphuric acid is carefully run in, the tube being sloped to receive the substance which will be found to settle below the milk layer. The tube is well and tightly stoppered, the number of the sample being recorded upon it. It is then wrapped in a duster and thoroughly shaken. After shaking, the precipitated casein is completely dissolved, leaving a dark-coloured liquid. The tube, balanced by others, is placed in the centrifuge, stoppered extremity towards the circumference of the machine, pockets being provided to hold the various tubes. The lid is screwed down and the machine spun rapidly for two minutes. The tubes are removed and held with the graduated end upwards. By manipulating the rubber stopper, the fat layer is brought within range of the graduations, when the percentage of fat may be read off direct. To correct for temperature, tubes should be placed in a water bath at 65° C. for three minutes before reading. If a fluffy layer appears at the base of the fat column, the test should be repeated, care being taken to see that the rubber bung is satisfactory. The sample may also have been centrifuged for an insufficient period or the addition of amyl alcohol may have been overlooked.

Another simple chemical test may be used with the same apparatus, in which the following solutions are required :

Solution 1. 37 parts Fusil Oil.
13 parts Wood Alcohol.
50 parts Hydrochloric Acid.
Solution 2. Sulphuric Acid diluted to twice its volume with water.

Five millilitres of milk are placed in the Gerber tube, and to this is added 1 ml. of solution No. 1. Sufficient of solution No. 2 is then added to the mixture to fill the tube to the lowest graduation. The whole is well shaken and centrifuged for two minutes. On removal, the percentage of fat is read off as before.

A few years ago Dr. S. Repetto of Italy introduced a new volumetric method of testing milk for butter fat following a large number of experiments personally undertaken. Ten millilitres of milk are placed in a Gerber butyrometer and 1 ml. of isobutyl alcohol added. To this mixture is added 10·5 ml. of sodium hydrate (6·5 per cent.). The tube is firmly shaken for thirty seconds and inverted, to render the solution homogeneous. It is then placed in a water bath at 140° to 144° F. for eight minutes. After being removed it is again shaken horizontally for some twenty to thirty seconds. It is next inverted four or five times, replaced in the water bath for three to five minutes, and finally centrifuged for four to five minutes. After centrifugalisation the tube is removed from the machine, replaced in the water bath for a few seconds at 140° F., after which the fat percentage is read off as before. If desired, the quantities of milk and sodium hydrate may be inverted with satisfactory results. Dr. Repetto claims that this method is 25 per cent. more economical than the Gerber method and that technique is extremely simple.

Although the Gerber and other tests are in general use in the dairy and are easily applied, results obtained by their application are not sufficiently accurate for legal work in connection with milk sampled for analysis under the Food and Drugs Act, 1938. For this reason, analytical laboratories prefer to make use of the "*Adams Coil*" method. With this technique, a 22 in. long by 2½ in. wide strip of absorbent filter paper is stretched between two clamps. Milk to be tested is thoroughly mixed and 5 ml. of the fluid are sprayed over the paper from a pipette. The weight of

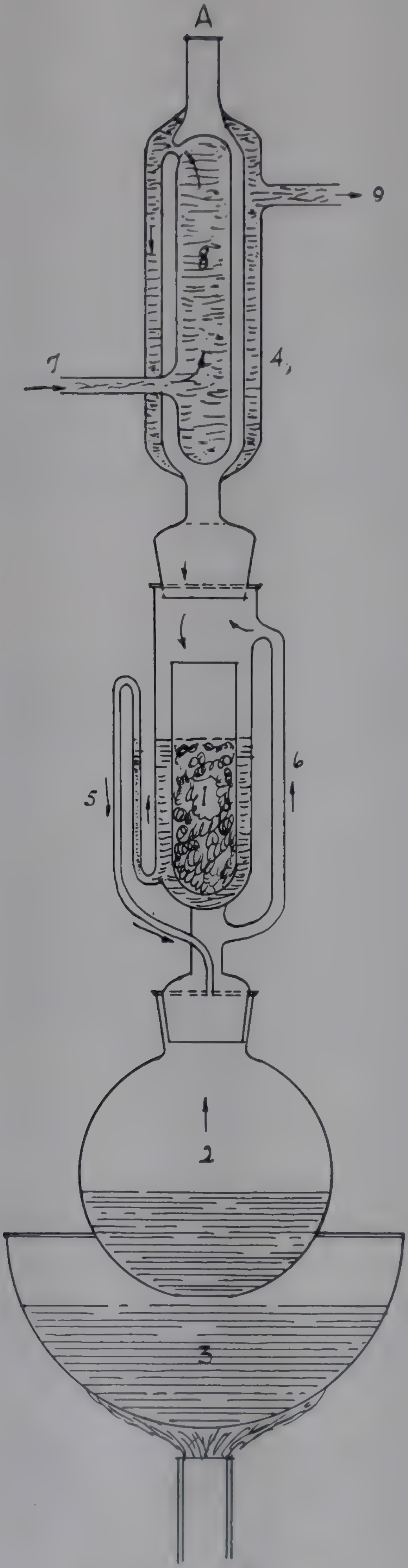


FIG. 208.

SOXHLET APPARATUS

1. Extractor.
2. Receiving Flask.
3. Water Bath.
4. Condenser.
5. Siphon.
6. By-pass to Condenser.
7. Water Inlet to Condenser.
8. Water Jacket.
9. Water Outlet from Condenser.

milk delivered by the pipette should be noted. The paper is then dried after which it is coiled to fit into the extractor of a Soxhlet apparatus as illustrated in Fig. 208. The coil is then dried at 100° C. Under the extractor is placed a receiving flask which has been previously weighed. The whole apparatus stands in a water bath heated by a Bunsen burner. The upper portion consists of a container, through which ether is passed, this being surrounded by a cold-water jacket. This portion of the apparatus acts as a condenser. Ether is poured into the inlet and flows into the extractor until the level of the ether reaches the top of the siphon. The whole volume of ether then siphons out into the receiving flask and a second charge is given, which again siphons into the receiver. The ether is maintained at boiling-point in the flask by means of the water bath, and ether vapour passes through the by-pass to the condenser, where it returns to its liquid form and again falls on to the coil in the extractor. The ether passing over the coil gradually dissolves the fat in milk, and, as the extractor fills, fat, together with the ether, is siphoned over into the receiver. Fat, being non-volatile, remains in the flask, while ether continues to circulate. The process is allowed to continue for three hours to ensure that all fat from the milk on the coil has been transferred to the flask. When the process has been completed the flask is removed and the ether distilled off. The flask is then dried at 100° C. for twenty minutes, cooled, and weighed. The increase in weight represents the fat extracted from 5 ml. of milk, the weight of such milk being determined by the specific gravity of the sample.

(3) **Total Solids.** In ordinary dairy practice the total solids may be roughly but quite satisfactorily determined from the lactometer reading and fat percentage as obtained by the Gerber method, using a " Richmond " or " Collins " scale rule.

The laboratory method of estimating total solids is as follows. A small, flat-bottomed platinum dish and a short stirring rod are weighed together. Five grams of well-mixed milk are added to the dish and a second weighing is made. The dish, rod, and contents are placed in a water bath for about one hour and the milk evaporated to dryness. The rod is used to break up the film of albumin which collects from time to time, and should always be replaced after use in the dish. When the dish with its contents is dry, it is removed to an electrically-heated air oven at 100° C., where it is given a further drying for a period of three hours. The contents are cooled and weighed, then heated for half an hour and re-weighed, heating and weighing being repeated until the last two weights are constant. The percentage of total solids can then be calculated.

(4) **Non-Fatty Solids.** The simplest way of calculating percentage of non-fatty solids in milk is by means of the " *Richmond* " *Scale.* The fat percentage as shown by the Gerber method is subtracted from the percentage of total solids, the result being the percentage of non-fatty solids present. The " *Collins* " slide rule may also be used for this purpose.

The separate solids whose presence in milk is generally estimated are :

(*a*) Ash.
(*b*) Milk Sugar or Lactose.
(*c*) Casein.
(*d*) Albumin.
(*e*) Protein.

(*a*) **Ash.** To obtain the percentage of ash, the dish, rod, and solids used in the examination for total solids are required and a further 5 grams of milk added, the whole being evaporated to dryness in a water-bath for one hour. The residue is then charred and heated in a muffle furnace until only a white ash remains in the dish. This is allowed to cool in a desiccator and weighed. This weight, less the known weight of the dish and rod, gives the weight of ash, from which the total percentage may be calculated by the following formula :

$$\frac{\text{Weight of ash} \times 100}{2\ (\text{Weight of sample used for total solids estimation})}$$

(*b*) **Milk Sugar or Lactose.** The percentage of milk sugar can be obtained by a simple calculation. The total weight of fat, protein, and ash is subtracted from the weight of total solids, and this gives the weight of milk sugar. The percentage can then be calculated.

A more accurate estimation may be obtained by the *polarimeter* or by *precipitation with Fehling's solution*, the latter method being the more common. For this method 10 ml. of milk to be examined are mixed with 100 ml. of water, and to this is added 1·5 ml. of 10 per cent. acetic acid solution. The whole is boiled, the whey filtered off from the solid matter and made up to 100 ml. with water. This whey contains all the milk sugar or lactose, together with the mineral salts. Twenty millilitres of whey are then poured into a burette. Fehling's solutions are now required and should be purchased made up in standard form. Five millilitres of each of these solutions are placed in a flask, diluted with 30 ml. of water and boiled. After boiling, 2 ml. of whey are run into the flask from the burette. The mixture is then boiled, when the blue tint of the liquid will fade. An additional 2 ml. of whey are added and the mixture is again boiled. When the colour has almost faded the whey is added in smaller quantities until a colourless liquid records the fact that the process is complete. Fehling's solution is oxidised by milk sugar and forms cuprous oxide, which shows as a sediment at the bottom of the flask. Standard Fehling's solution requires 0·0678 gram of milk sugar to reduce 10 ml. of solution. A simple calculation of the amount of whey necessary to reduce the copper in 10 ml. of the solution used will give the quantity of milk sugar in the sample.

A second chemical method may be employed, as follows : Five millilitres of thoroughly mixed milk are placed in a 50 ml. flask, and to this mixture is added 25 ml. of distilled water, 2·5 ml. of sodium tungstate, and 2·5 ml. of $\frac{2N}{3}$ sulphuric acid, the total quantity of the mixture being brought up to 50 ml. by addition of distilled water. The flask is stoppered, thoroughly shaken, and allowed to stand for a few minutes to allow the precipitate to floculate. The liquid is then filtered and titrated by means of Benedict's solution which is a mixture of sodium citrate, sodium carbonate, potassium thiocyanate, copper sulphate, and potassium ferrocyanide in water. The calculation is made as follows :

Suppose 10 ml. of milk filtrate reduces 25 ml. of Benedict's solution.
Then, as the milk is diluted 1 in 10
1 ml. of whole milk = 25 ml. of Benedict's solution.
25 ml. Benedict's solution = 0·0678 gram lactose.
∴ 1 ml. of milk = 0·0678 gram lactose.
100 ml. of milk = 6·78 gram lactose
Lactose = 6·7 per cent.

Determination of Nitrogen in Milk

Before dealing with the determination of casein, albumin, and protein contained in milk, the *Kjeldahl method* of determining nitrogen content may be mentioned, as this forms the basis of further tests to be described.

Briefly, Kjeldahl's method is as follows. Ten millilitres of milk are weighed out into a glass flask, two or three ropes of concentrated sulphuric acid are added and the flask is submerged in a boiling-water bath until the sample is practically dry. Twenty-five millilitres of strong sulphuric acid, 10 grams of powdered potassium sulphate, and one small crystal of copper sulphate, about 0·1 gram, are added. Flask and contents are gently heated until the contents are thoroughly carbonised. The mouth of the flask is then placed within a draught pipe which carries off the fumes of the acid, and the whole is strongly heated until a clear-blue liquid is obtained. During heating, the organic matter is completely broken up, any nitrogen from proteins and other allied compounds being converted into ammonia which is the clear solution remaining in the flask. This solution is then washed out of the flask into a copper vessel with distilled water. A few drops of litmus solution and 5 grams of granulated zinc are added and finally 75 ml. of 50 per cent. by volume caustic-soda solution are added, and the condenser tube is fitted with a water trap. A condenser is also fitted to the copper vessel. The receiver contains 50 ml. N/10 sulphuric acid slightly coloured with methyl orange as an indicator. This is placed below the condenser, heat being applied to the liquid in the copper vessel. The solution on boiling frees ammonia, which gas passes to the condenser with the steam and falls into the sulphuric acid. The distillation process is carried on until the ammonia has completely passed over. The receiver is then removed and the liquid titrated drop by drop with normal caustic-soda solution until the red colour of methyl orange changes to yellow. The amount of caustic soda required to bring about this conversion is noted. Each millilitre of normal sulphuric acid will combine with exactly 0·017 gram of ammonia or 0·014 gram of nitrogen, while every millilitre of caustic-soda solution will combine with 1 ml. of normal sulphuric acid. The method of calculation is as follows :—

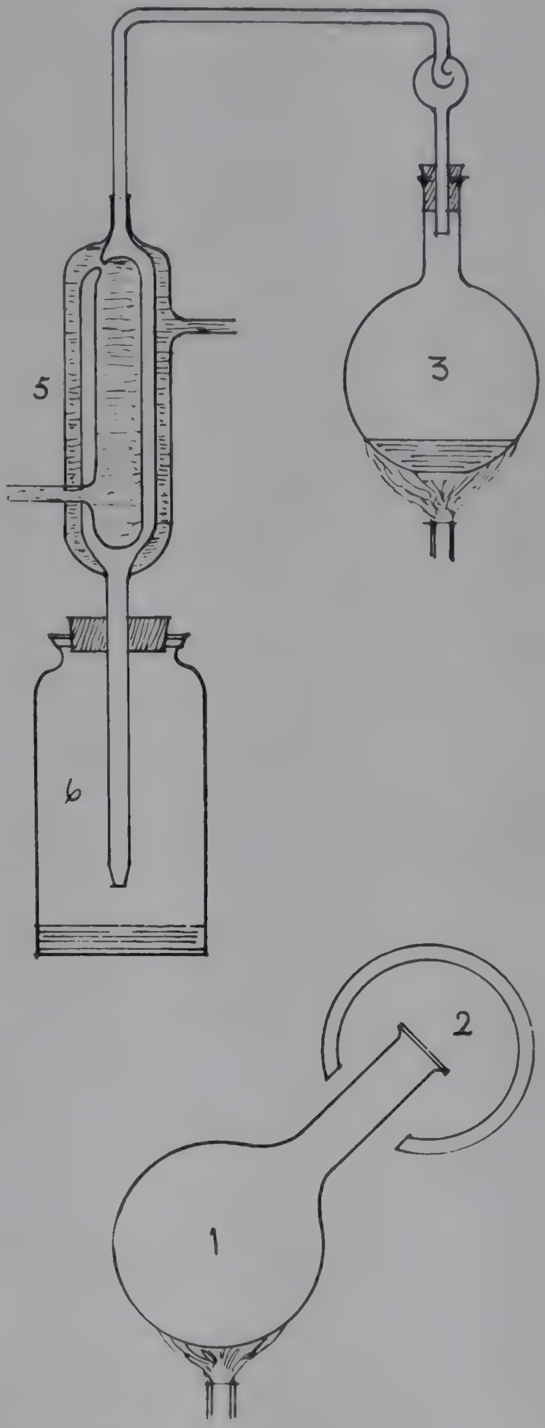


FIG. 209.

KJELDAHL'S APPARATUS

1. Glass Flask.
2. Draught Pipe.
3. Copper Vessel.
4. Water Trap.
5. Condenser.
6. Receiver.

$$\frac{10 - B \times 0{\cdot}014 \times 100}{A} = \text{Percentage of nitrogen.}$$

where A = Weight of milk in grams ; and
B = Amount of normal caustic soda required to neutralise the acid in the receiver.

The percentage of protein equals the amount of nitrogen multiplied by 6·38.

(*c*) **Casein.** The casein content of milk is rarely determined in dairy examinations. When this estimation is carried out, 10 ml. of fresh milk are placed in a beaker and to this is added 50 ml. of distilled water at 40° C., followed by 1·5 ml. of 10 per cent. acetic acid. The mixture is thoroughly stirred and allowed to stand for twenty minutes to allow the casein to settle. At the end of this period, 4·5 ml. of 0.25 N sodium acetate solution are added and, after stirring, the whole mixture is allowed to stand for one hour. The liquid is then filtered, the precipitate well washed, and the amount estimated by calculating its nitrogen content by the method already described, multiplying the figure so obtained by 6·38. Another method of estimating casein content of milk is as follows. Ten grams of milk are added to 100 grams of water and placed in a tall glass jar. Two grams of 10 per cent. solution of acetic acid are added to this diluted milk. The mixture is allowed to settle for five minutes, when a stream of carbonic-acid gas is passed through, causing precipitation of casein. The liquid is siphoned off, leaving the casein behind. This is collected on a weighed filter paper, washed, dried thoroughly, and re-weighed. The difference in weights gives the weight of casein.

(*d*) **Albumin.** To obtain the quantity of albumin present in milk, the liquid whey obtained by siphonage in the last-mentioned process is boiled for several minutes. The albumin coagulates at the bottom of the vessel and the liquid is drained off. The albumin is collected on a weighed filter paper washed, dried thoroughly, and re-weighed. The difference in weights gives the weight of albumin. The quantity of albumin present may also be calculated by neutralising the filtrate obtained in the process of casein estimation already described, by means of 10 per cent. caustic-soda solution. Three-tenths of a millilitre of 10 per cent. acetic acid is added and the whole heated until the albumin is completely precipitated. The albumin is filtered and washed, and the nitrogen value obtained by the Kjeldahl method. The nitrogen value multiplied by 6·38 gives the amount of albumin present.

(*e*) **Protein.** Milk proteins contain approximately 15·8 per cent. of nitrogen, so that, in analysing milk for protein, the percentage of nitrogen is first obtained. The percentage of protein is calculated by multiplying the figure obtained by the protein factor of milk, which is 6·38, and again multiplying the resulting figure by 0·94.

(5) **Tests for Added Water.** The addition of water to milk is the simplest and most likely form of adulteration. One might expect that its detection would be equally simple. Remembering that the specific gravity of full-cream milk is approximately 1·035 and that of water is 1·0, it might appear that milk had been watered when the specific gravity was found to be below normal. It might be thought that it would be a simple matter to find the specific gravity of a sample suspected of adulteration, and calculate the difference between it and that of the genuine article, but unadulterated milk is so complex and variable in its composition that any calculations based on this principle would probably be a long way from the truth.

A simple, though rough method of carrying out this investigation is to examine the total solids, following the evaporation test, for the presence of *nitrates* or *nitrites*, which are in some instances an indication of added water. The freezing-point test shortly to be described is now, however, the generally accepted laboratory method of proving the addition of water to milk.

Added water may be suspected under the following circumstances:

(*a*) Fat percentage below 3 per cent.
(*b*) Percentage of non-fatty solids below 8·5 per cent.
(*c*) Percentage of total solids below 11·5 per cent.
(*d*) Percentage of ash below 0·65 per cent.
(*e*) Freezing-point nearer to zero than − 0·550° C.
(*f*) Specific gravity less than 1,027.
(*g*) Refractive index less than 37.

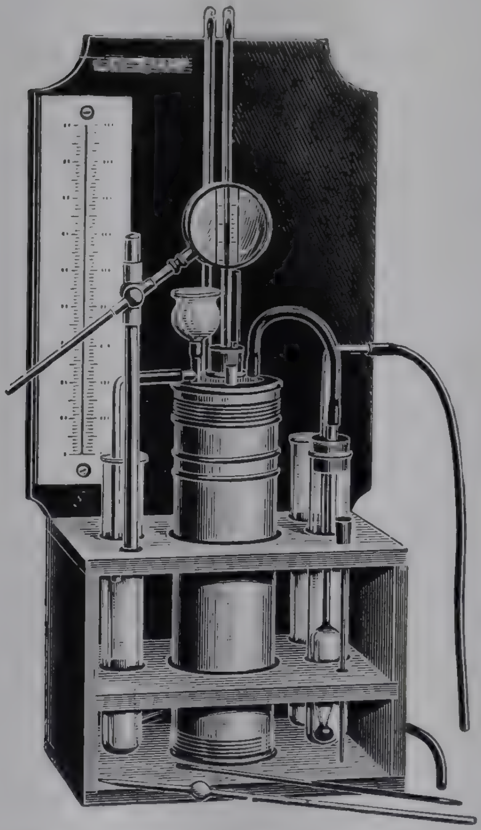
It must be reiterated that the above facts only point to suspicion of added water, it being impossible to differentiate between watered milk and milk which is naturally poor in fatty or non-fatty solids by the practical use of the above data.

To calculate the approximate percentage of added water, multiply every decimal of the percentage of solids-other-than-fat below 8·5 by 12. Thus, milk containing 8·1 per cent. of non-fatty solids would be assumed to contain 4·8 per cent. added water. Although this is sufficiently accurate for practical use, it is not sufficient for legal purposes. For this reason, the *freezing-point method* of testing for added water is now employed in analytical laboratories. The freezing-point of milk is determined by the *cryoscopic method*, and is generally accepted to be −0·550° C. The addition of water brings the freezing-point closer to zero.

In the past, the principal difficulty met with in connection with chemical examination of milk samples has been the certain detection of added water, chiefly due to lack of an absolute standard for milk. The standard provided is merely presumptive, being based on analytical figures, which figures may be rebutted if any direct evidence can be presented to the effect that no interference has taken place with milk. It has also been held that it is not an offence to sell milk which does not conform to the presumptive standards, provided it is sold exactly as drawn from the cow. A third difficulty has been the fact that proof of added water in milk has always been inferential. Although genuine milk usually contains some 87·5 per cent. of water, other samples, though genuine, may contain more or less. Milk is divided for the purposes of analysis into the constituents of fat, non-fatty solids and water, this being the basis of the Sale of Milk Regulations. This division has been found to be unsatisfactory, and non-fatty solids have been further subdivided by chemists into lactose, protein, and ash. Dr. P. Vieth has found that, in normal milk, these three constituents have a constant ratio one to another in the proportions of 13 : 9 : 2. Vieth's ratio provides a means of distinguishing naturally poor milk from milk rendered poor artificially by addition of water, and he proved that no matter how much water was added to milk, ash would still remain one-twelfth of the total solids. This provides a strong line of evidence. The determination of protein content is a difficult chemical process but ash and lactose contents can be readily determined. Because of changes which occur in lactose, even before souring takes place, the percentage of this substance can only be determined when milk is fresh. For this reason it is desirable that milk should reach the analyst at the earliest possible moment after sampling, maintained, if necessary, in a sweet condition by means of ice. Owing to the prolonged and delicate method of estimation entailed, together with the necessity for an "appeal to the cow" sample this method was not entirely satisfactory.

It is now approximately forty years since the idea of a freezing-point test to estimate the quality of milk was first mooted, and since that time a steady advance has been made in the technique employed. The rationale of this test is the application of osmotic pressure. Milk is elaborated from blood, and it is assumed that the osmotic pressure of milk, if not identical with that of blood, will at least bear some definite relation to it. As the osmotic pressure of blood does not vary within wide limits, it is also assumed that that of milk will be equally constant. Since osmotic pressure of milk is reduced by addition of water, the determination of this pressure is a means of indicating the presence of added water. The osmotic pressure of a substance is difficult to determine, therefore it is fortunate that there is a definite relationship between the osmotic pressure of a substance and its freezing-point. Lactose and mineral salts in milk are in true solution, and it is these substances which produce osmotic pressure, which in turn depresses the freezing-point. If water is added to milk, the concentration of the lactose and mineral salts will be diminished, the result being that the freezing-point will approximate closer to that of water.

The freezing-point apparatus now used owes its present form to an American chemist, Hortvet. Hortvet has designed an apparatus for carrying out the test in which conditions and procedure are standardised, so that, for practical purposes, any correction factors may be omitted. This instrument has been adopted by public analysts in this country and is now the most reliable means available for detection and determination of added water in milk. The apparatus is simple in design and application. As has already been mentioned, the freezing-point of average cows' milk is taken to be —0·550° C., although variations from cow to cow may cause this figure to vary between —0·530° C. and —0·570° C. The figure —0·053° C. has been accepted as a basis for calculation of added water by this method, the vendor of the milk thus receiving the benefit of the variation.



By courtesy of Sutherland Thomson & Co.

FIG. 210. Hortvet Cryosc

The *Hortvet Cryoscope*, illustrated in Fig. 210, consists of a cylindrical vacuum flask of 1 litre capacity, surrounded by a metal casing to ensure constant temperature. The neck of the flask is closed by a large cork through which passes a metal tube holding the freezing tube; a metal inlet tube, the lower end of which is in the form of a perforated loop reaching almost to the base of the flask; a metal T-shaped tube; apertures for the gauge tube, and a control thermometer. A standard thermometer reading from —1° C. to —2° C. is also fitted through the rubber stopper of the freezing tube. A metal stirrer is fitted through the same stopper, which has a third aperture for inserting the freezing starter. On the right of the cryoscope is fitted an air-drying apparatus connected to a rubber bellows, while on the left is a drain tube to collect the vapours. An adjustable lens is fitted to magnify the thermometer readings, and the whole apparatus is mounted on a wooden stand. A scale is fitted to the stand showing percentages of added water.

Sufficient strong sulphuric acid is placed in the air-drying tube to cover the bulb, while 400 ml. of ether, previously cooled to 10° C. or lower, are poured into the T-shaped tube. This tube is then closed by a small cork, and air is passed through the apparatus by means of rubber bellows until the control thermometer registers −3° C. The gauge tube is then lowered into the ether bath, the top closed with the forefinger, and the amount of ether necessary to restore the 400 ml. volume estimated. It will usually be found that 10 to 15 ml. suffice for this purpose. The necessary quantity is added, a small quantity of alcohol being also poured into the metal tube. Some 30 to 35 ml. of milk previously cooled to 10° C. (sufficient to cover the bulb of the thermometer) are then placed in the freezing tube which is inserted in the metal tube. The stirrer is kept in motion in a longitudinal direction at the rate of one stroke per second. Air is passed through the apparatus to maintain the temperature of the cooling bath at 2·5° C. below the probable freezing point of the sample. Super-cooling of the sample will take place at approximately 1° C. below the actual freezing-point. When this temperature is reached, it is often necessary to insert the freezing starter with a small quantity of ice, when a rapid rise in the mercury column will result. The stirrer is operated slowly several times as the mercury column approaches its highest point, and the top of the thermometer is lightly tapped until the mercury remains stationary for at least one minute. The reading of the thermometer is noted and estimation to 0·001° C. made. The percentage of added water is accurately determined by comparison with the scale fitted on the stand. Broadly speaking, each 0·01° C. indicates approximately 2 per cent. added water. The formula for determining the definite percentage of added water is :

$$W \frac{100\,(T - T^1)}{T}$$

where W = Percentage of added water.
T = Original freezing-point.
T^1 = Freezing-point of sample.

It is sometimes necessary to correct for acidity. For every 0·01 per cent. of lactic acid by titration below 0·17 per cent. add 0·01° C. to temperature, and for every 0·01 per cent. above 0·17 per cent. add 0·003° C. The apparatus should be checked occasionally by carrying out a test with well-boiled distilled water cooled to 10° C. or lower in place of milk. The result must be 0° C. in every case and any deviation from this figure should be used to correct ensuing tests.

The significance of the freezing-point test has been admirably summed up by Elsdon and Stubbs, who have stated :

> "Our work on the freezing-point test for milk proves that it is really a test of some outstanding significance, yielding information surpassing in reliability that obtained from other tests, and that the indications it gives may be safely accepted."

One disadvantage of this test is the fact that, to be entirely successful, milk must be fresh, as with sour or slightly sour milk the lactose in such samples is decomposing, giving rise to acids which possess a higher osmotic pressure. The acidity of fresh milk varies from 13 to 18 on the scale and, if the acidity of any sample exceeds 22, it is not advisable to carry out the test.

This disadvantage precludes its use unless the laboratory is situated within a convenient distance of the place at which the sample has been taken.

Other disadvantages of the Hortvet apparatus are:

(1) Manual control of the cooling agent.
(2) Time required for the completion of each test.
(3) Employment of ether, the vapour from which is a potentially dangerous substance.

Temple has reported that by using calcium chloride solution suitably concentrated to freeze at − 2·3° C., and employing entirely automatic temperature control of the cooling agent, it is possible to obtain a substantial saving in time and material as the number of tests made can be greatly increased.

(6) **Tests for Heated Milk.** It is sometimes necessary to determine whether milk has been efficiently heated, and this is particularly important in the case of pasteurised and other heat-treated milks. Tests for the presence of *peroxidase* and *phosphatase* are used in this determination, both enzymes being destroyed by heat. The tests in common use are:

(*a*) *Guaiacum Test.* A few drops of tincture of guaiacum containing guaiaconic acid are added to a test-tube half-filled with milk. The positive reaction of heated milk is shown by the formation of a greenish-blue zone where the two liquids meet.

(*b*) *Storch's Test.* Five millilitres of milk are placed in a test-tube and to this is added one drop of a 0·2 per cent. solution of hydrogen peroxide containing 0·1 per cent. sulphuric acid, and 2 drops of a 2 per cent. aqueous solution of paraphenlenediamine hydrochloride. The whole is well mixed. The rapid production of a blue or dark violet colour indicates a positive reaction.

(*c*) *Potassium Iodide-Starch Test.* A few drops of a 5 per cent. aqueous solution of potassium iodide, a small amount of starch solution, and a few drops of hydrogen peroxide are added to a test-tube half-filled with milk. A blue colour indicates a positive reaction.

(*d*) *Ortol Test.* One drop of 0·5 per cent. ortol solution and 2 drops of a 0·2 per cent. hydrogen-peroxide solution are added to 10 ml. of milk. A positive reaction is indicated by the appearance of a mauve-red colour.

(*e*) *Phosphatase Test.* This modern test is of such importance that detailed consideration and technique are set out below.

The Phosphatase Test

No consideration given to tests for heated milk can be complete without a description of the invaluable phosphatase test and its use in detecting errors of pasteurisation. In the past, the only method by which it has been possible to ensure that the milk has been held during processing at the requisite temperature for the prescribed time, has been by submitting the product to frequent bacteriological examinations combined with inspection of plant and methods employed. While such inspections are still essential, to be of any value they must be carried out at frequent intervals and they are not conclusive evidence in themselves that correct operation is always maintained. It cannot be denied that the experienced official may be able to satisfy himself by inspection that possible sources of trouble in the plant might be avoided. A practical inspection, combined with a bacteriological examination of the product has, in the past, assisted in deciding whether or not a plant has been functioning in an efficient manner. As might be readily understood, this procedure, if carried out with the necessary frequency, is likely to occupy too much of the official's time, and this has led to the need for a quicker, more certain and efficient method of estimating the accuracy of processing.

One other important point which has to be considered is that a considerable quantity of milk may be sold in one area which may have been pasteurised in an adjoining district and the responsible official has found himself unable to inspect either plant or methods. Even when inspection shows that plant is apparently operating in an efficient manner, slight errors can arise which may be difficult to discover. While in the past reliance has had to be placed upon bacteriological control and while the plate count and other tests should still be employed in conjunction with the method of examination to be outlined, it must be remembered that such tests are liable to considerable sources of error on account of weather conditions, time between treatment and sampling, and individual faults in technique which may arise when such examinations are made. For these reasons, many tests based on the effects of heat upon the cellular, physical and chemical properties of milk have been subject to experiment, but none have been found to be entirely reliable as indicators of improper processing methods. On account of such failures no person interested in the control of pasteurisation will surely disagree with the statement that the phosphatase test, originated by Kay and Graham, is a welcome solution to the difficulties experienced in exercising efficient control of processing. No other test can supply the same or comparable information regarding the efficiency of pasteurisation.

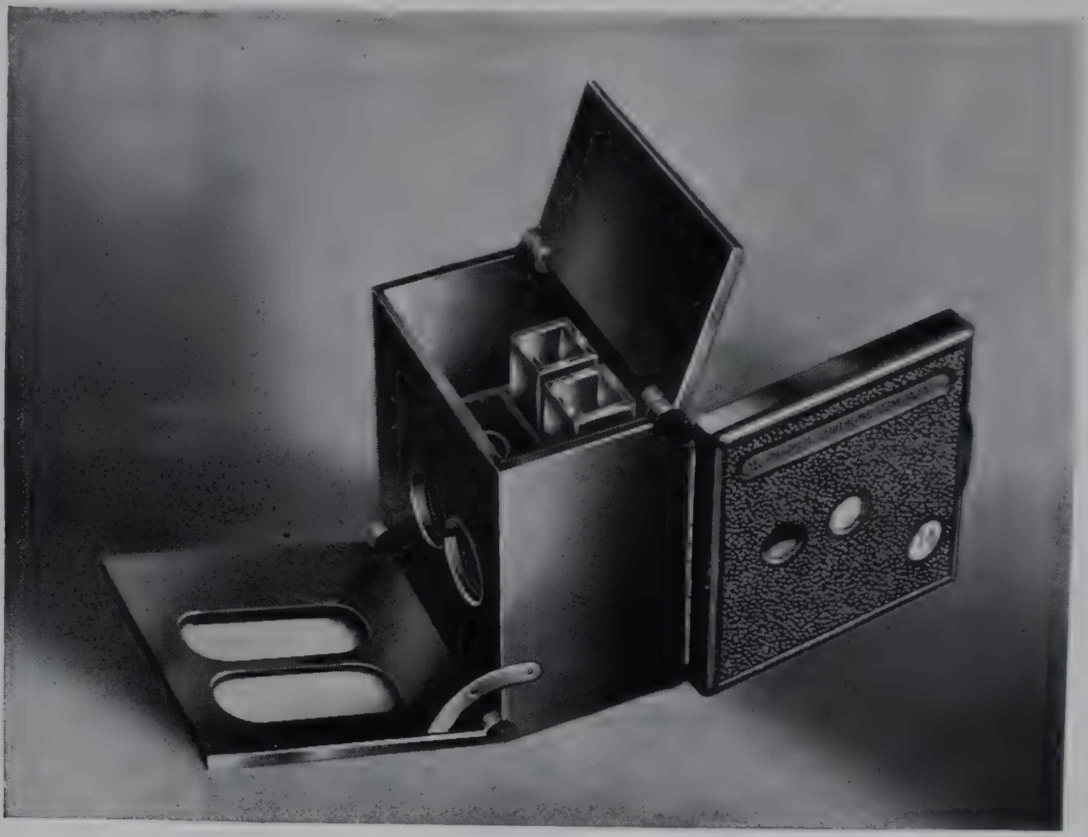
The test depends for its success upon the fact that the enzyme, *phosphatase*, which is a constant constituent of raw milk, is completely destroyed by processing within the specified time and temperature limits prescribed either for low-temperature or high-temperature, short-time processes. This enzyme may be readily detected and its presence in a sample of milk is evidence that the liquid has not been satisfactorily processed. If the required temperature has not been attained, or if such temperature has not been maintained for the requisite period, the enzyme survives to a greater or lesser degree. From a public health point of view it is important that all pathogenic organisms should be destroyed at a lower temperature than that used for processing or after slightly shorter periods of exposure. Apart from guinea-pig inoculation, therefore, a negative phosphatase test is the best guarantee that a sample of pasteurised milk is free from tubercular organisms while, when the thermal death-points of other pathogenic organisms are considered (see page 336), it also proves its freedom from organisms likely to be injurious to the health of the consumer, always excepting any case of recontamination after treatment. On the other hand, a positive result indicates that processing has erred and shows that milk has not been heated to the required temperature or has not been retained at the temperature for the necessary period. It may also indicate that, through some fault in plant or processing, raw milk has been permitted to mix with the pasteurised product, an admixture of 0·2 per cent. of such milk being detectable. The fact that agitation has not been used in an effort to bring about an apparent increase in cream-line and that there has been uncontrolled or excessive foaming with a consequent low temperature of foam is also demonstrated. Among the grosser errors which may be discovered are :—

(1) Deliberate omission of the holding period.
(2) Carelessness in operation.
(3) Fluctuations in temperature due to manual control.
(4) Poor or defective equipment.

It will rarely be found that the operator is deliberately under-pasteurising his product or wilfully adding raw milk to the processed article. If such cases are discovered, the offender's licence should be cancelled and a prosecution should follow. Usually, faults in processing are due either to an unexpected breakdown or to a careless or unreliable employee.

The following *apparatus* is required in making the test :

(1) A Lovibond All-Purposes Comparator as shown in Fig. 211. This possesses two 25 mm. glass cells and has a standard disc containing four blue colour standard glasses, which contain 0·5, 1·5, 2·3 and 6·0 Lovibond units of blue. A wooden block is provided to fit inside the apparatus and hold the cells firmly. If desired, the Lovibond Comparator as described for use in making the Resazurin test (page 385), and shown in Fig. 197, may be employed.



By courtesy of the Tintometer Ltd.

FIG. 211. Lovibond Comparator (used for Phosphatase Test).

(2) An incubator or water-bath, thermostatically controlled at 37° C.

(3) A pipette to deliver 4·5 millilitres, preferably of dark glass.

(4) A number of 0·5 millilitre, straight-sided pipettes, the mouthpieces of which should be plugged with cotton-wool. One pipette is required for each sample to be examined.

(5) A pipette to deliver 2 millilitres.

(6) Test-tubes marked at the 10 ml. level, provided with phenol-free rubber stoppers. One tube is required for each sample to be tested. Before use, they should be cleansed with chromic acid.

(7) Filter funnels and stand, together with a supply of Whatman No. 40 filter papers.

(8) The following reagents are also required :

- (*a*) *Buffer-Substrate Solution.* This contains 1·09 grams disodium phenyl-phosphate buffered with 11·45 grams sodium diethyl barbiturate and made up to 1 litre with distilled water. This solution should be saturated with chloroform, and will remain stable for forty-eight hours if stored in a refrigerator. If it is to be kept for longer periods, it should be tested before use. It is more convenient to use standardised tablets for the production of this solution, one tablet being dissolved in 50 ml. distilled water, and the solution saturated with chloroform.

(*b*) *Folin and Ciocalteu's Phenol Reagent.* This must be diluted with twice its volume of 5 per cent. (weight per volume) sodium hexametaphosphate solution before use. This mixture must be carefully protected from dust or any reducing substance.

(*c*) *Sodium Carbonate Solution.* A 14 per cent. solution (weight per volume) of pure anhydrous sodium carbonate, which should be standardised by titration.

In making the test, certain *precautions* must be observed. These are :

(1) Apparatus and the test reagents, which must be rigidly standardised and obtained from an approved source, must be stored at a safe distance from phenols or any articles containing phenols. It should be noted that difficulties in testing have been experenced through the use of impure reagents.

(2) All reagents must be stored in a cool, dark place and protected from dust.

(3) Glass bottle stoppers and caps should be used.

(4) Rubber stoppers must be tested for phenolic impurities.

(5) Before use, all glassware must be carefully cleaned in chromic acid, experience having demonstrated that new glass may carry enough phenol to produce a blue tint.

(6) Contamination of pipettes with saliva which contains phosphatase must be avoided.

(7) Tests must not be carried out in direct sunlight.

(8) Freshly boiled distilled water must be used for dilution purposes.

The *technique* of the test is set out in the Addendum to Memo. 139/Foods of the Ministry of Health and is carried out in the following manner. Samples kept at room temperature should be examined within eighteen hours of processing in every case although, if this is not possible, they may be stored in a refrigerator until examined. If this latter procedure is adopted, care must be taken to ensure that each sample is raised to room temperature before the examination takes place. All tests should be carried out in duplicate. Ten millilitres of the buffer-substrate solution are run into each of two test-tubes graduated at the 10 millilitres mark and to each tube is added 0·5 millilitre of the well-mixed sample. Three drops of chloroform are added to each tube and these are sealed with sterile rubber stoppers, the contents well mixed and incubated either in a water-bath or an incubator, at a temperature of 37° C. for twenty-four hours. At the expiration of this period they are removed from the bath, cooled, 4·5 millilitres of test reagent solution added to each, and they are then allowed to stand for three minutes. Their contents are then filtered into tubes. fresh After filtration, 2 millilitres of the 14 per cent. solution of sodium carbonate are added to each tube containing 10 millilitres of filtrate, the whole being well mixed. The tubes and their contents are placed in water which is kept continuously boiling, where they remain for two minutes. The mixture is cooled, filtered if necessary, and transferred to the right-hand comparator cell, a blank containing distilled water being placed in the left-hand aperture.

The comparator is placed so that it faces a good source of daylight—north light, if this is possible—direct sunlight being avoided, and the colour disc is rotated until a reading is obtained. The results are returned as shown in Table 20.

TABLE 20

Units of Blue	*Results described as :*
Below 2·3 units	Negative phosphatase test.
2·3 to 6·0 units	Insufficiently heat-treated.
Over 6·0 units	Grossly under-treated.

Raw milk usually gives a reading of over 30 units of blue, therefore a reading above 2·3 units may indicate either incorrect treatment or addition of raw milk. No differentiation between the probable causes is possible on the results shown.

The remainder of the milk which is being tested should be stored in a refrigerator until the incubation period of the samples under test is completed when *control tests* should be carried out on fresh portions of milk from those samples which give a reading above 2·3 units of blue. In these tests, 10 millilitres of the buffer-substrate solution are mixed with 4·5 millilitres of the test reagent, 0·5 millilitre of milk being added and the whole well mixed. This mixture is allowed to stand for three minutes and is then filtered into a graduated test-tube after which 2 millilitres of sodium carbonate solution are added to 10 millilitres of filtrate. The contents of the tube are well mixed, following which the tube is placed in boiling water for two minutes. The mixture is cooled, filtered if necessary, transferred to the comparator cell and the disc read. The colour of the liquid should not exceed 1·5 units of blue. If a higher reading is obtained the presence of phenolic substances is indicated. These would not be evident if the milk had been correctly pasteurised or if it was uncontaminated. Such a reading may also indicate faulty reagents or technique. If two or more samples examined at the same time show a control reading above 1·5 blue units, it may be assumed that either reagents or technique are at fault.

It should be noted here that reports received from the United States of America suggest that certain heat-resistant organisms found in milk are capable of producing a type of phosphatase which may effect the result of the test although it is emphasised that the type of enzyme produced differs considerably from that normally present in milk. This point, however, must necessarily be borne in mind.

A *test of reagents* is carried out by incubating a tube containing buffer-substrate solution and chloroform but without milk with each batch of samples, the test being completed in the usual way. When measured in the comparator, the resultant colour should not exceed 0·5 Lovibond units of blue.

The advantages to be derived from the test are set out below and are so obvious that its application to the routine control of pasteurisation must now be recognised as essential. These are:

(1) It is rapid in action.
(2) It is capable of being carried out on small samples.
(3) It is reasonably simple and cheap.
(4) The error of experiment is comparatively negligible.
(5) It is capable of detecting small errors in processing.
(6) On account of the temperature at which the enzyme phosphatase is destroyed, it bears a known relationship to the thermal death-rate of pathogenic organisms.

The following list shows errors or defects in treatment which have been revealed by the test.

(1) *Inadequate Holding Period.*
    (*a*) Leaking outlet valves.
    (*b*) Deliberate shortening of holding period.
    (*c*) Fast recording thermometers.
    (*d*) Wrongly connected valves in multiple compartment plant.
(2) *Low Temperatures indicated by the Recorder.*
    (*a*) Compartments only partially filled with milk and not maintaining temperature.

- (*b*) Cold compartments at commencement of processing.
- (*c*) Draughts from doors and windows affecting holder.
- (*d*) Poor insulation of holder compartments.
- (*e*) Poor agitation allowing a cool layer of milk at the bottom of the holder compartments.
- (*f*) Steam-raising boiler for plant of insufficient size. When sterilisation of bottles and churns was in progress at the same time as processing, the boiler could not cope with the extra output of steam demanded and the temperature of the heating medium fell considerably.

(3) *Low Temperatures not shown by Recorder.*

- (*a*) Thermometer bulb passing through heated jacket.
- (*b*) Improperly pasteurised foam contaminating last-drawn milk from holder compartments.
- (*c*) Thermometer bulbs touching metal lining of vat.
- (*d*) Breakdown of recorder.
- (*e*) "Cold pockets."
- (*f*) Failure to test thermometers at frequent intervals.

(4) *Added Raw Milk.*

- (*a*) Defective or improperly-closing valves.
- (*b*) Leaking regenerators.
- (*c*) Milk passing over surfaces previously used for handling raw milk.

The test is one which gives the operator and the controlling official detailed information regarding laxity in plant management which could be obtained in no other certain manner. Pasteurised milk no longer depends upon the consumers' confidence for its reception as a safe milk. It is now possible to prove whether or not this is so. It is quite certain that, in the past, much milk sold under the designation "Pasteurised" has been insufficiently processed, particularly as many plant operators attach particular importance to cream-line and accordingly may either reduce temperature or period of heating slightly with this end in view. From the standpoint of milk supervision, the important contribution this test makes is that heat-treatment given to milk can now be accurately determined from the milk itself at any point after processing. This is the contribution of the test and it is one which all controlling officials have sincerely welcomed. It is suggested that the failure of any operator to comply with the test on three successive occasions should be regarded as giving grounds for the withdrawal of a licence to produce or retail milk of this grade.

(7) **Refractive Index of Milk.** To determine the refractive index of milk, a copper-sulphate serum is used in conjunction with the *Zeiss immersion refractometer.* The refractive index of a genuine sample of milk is usually taken as 38·35, with a range varying from 37·0 to 39·0, whereas mixed milk low in solids other than fat possesses a refractive index below 37. Added water reduces the refractive index, a reduction of 1° on the scale indicating the addition of approximately 5 per cent. of water. Acidity increases refraction of the sample but it is impossible to state the point at which the degree of acidity attained in a sample renders the reading unreliable.

The refractive index generally approximates closely to the non-fatty solids figure and its employment as a method of detecting the added water in milk has been stated, by some workers, to be the most satisfactory means of ascertaining adulteration. This is probably an exaggerated opinion. The non-fatty solids figure, however, is a more reliable indication of added water, although neither can differentiate between milk which has been watered and milk naturally poor in non-fatty solids.

Variations in the Analytical Values of Adulterated Milk

The following table, compiled by Cherry-Burrell, Ltd., shows the variations in specific gravity of milk, percentage of fat, and other solids, etc., which may occur due to the addition of water or the skimming of cream.

TABLE 21

Type of Adulteration.	Watering.	Skimming or Addition of Skimmed Milk	Watering and Skimming.
Specific Gravity of Milk .	Decrease	Increase	Usually no change, but sometimes decrease (never increase).
Percentage of Butterfat. .	Decrease	Decrease	Very marked decrease.
Percentage of Solids . .	Decrease	Decrease usually (if skimming considerable).	Decrease.
Percentage of Non-fatty Solids	Decrease	Usually no change. Sometimes slight increase.	Decrease.
Cryoscopic Point . . .	Increase	No change	Increase.
Specific Gravity of Whey .	Decrease	No change	Decrease.
Refraction Index . . .	Decrease	No change	Decrease.
Soluble Matter . . .	Decrease	No change	Decrease.
Acidity	Decrease	Increase usually	Slight decrease.

Control of Milk from a Chemical Standpoint

Full powers are supplied under the various enactments dealing with milk as a food, set out on pages 428 to 434, to ensure a satisfactory control of milk supplies as regards chemical standards. These powers are exercised by the various Authorities operating the Food and Drugs Act, 1938, and appear satisfactory. More uniformity in sampling, particularly in the direction of increased numbers, is, however, called for, as, unless the work is carried out in a thorough and complete manner, much of the desired effect will be lost.

In passing, it may be stated that the existence of fixed standards for chemical composition of milk as retailed to the public, whereas no standard as to the cleanliness of the product is considered necessary, is an anomaly which requires explanation and immediate amendment.

CHAPTER XI

LEGISLATION

THE multiplicity of legislation which provides powers for control of the nation's milk supplies has been specially designed for this purpose and, when properly used, is of considerable assistance. Difficulties continually arise in the administration of these powers and, while in many cases they are deplorably vague, there can be little doubt that lax or indifferent administration is the cause of many problems with which those responsible for milk control are confronted to-day. While admitting this fact, it must also be stated that the enactments are often extremely indefinite. For this reason, clarification of all legislation applying to production and distribution of clean and safe milk, and particularly a standard code of practice universally applied, is an urgent necessity. It might be argued that the years immediately prior to the present war saw some clarification of the law relating to production and distribution of milk. This may be granted, but the war years have produced a number of amendments and additions and the available legislation is now in quite as chaotic a condition as it was before any attempt at simplification took place.

The legal powers dealing with milk, its production and distribution, are to be found in the various Acts, Orders and Regulations set out in chronological order below, together with the Sections or parts thereof applying to the control of milk supplies.

Act or Order	Section or Article Applying
Public Health (Prevention of Tuberculosis) Regulations, 1925	4–5–6–7.
Milk and Dairies Order, 1926	4–6–7–11–12–13–14–15–16–17–18–19–20–21–22–23–24–25–26–27–28–29–30–31–32–33.
Public Health (Imported Milk) Regulations, 1926	3–4–5–6.
Public Health (Infectious Disease) Regulations, 1927	10–11. Schedule I, Part I.
Milk Act, 1934	9
Public Health Act, 1936	79–80–149.
Public Health (London) Act, 1936	93–94–144.
Milk (Special Designations) Order, 1936	3–4–5–6–7–8–9–10–11.
Agriculture Act, 1937	20.
Food and Drugs Act, 1938	13–17–18–20–21–22–23–24–25–26–40–41–42–65–66–67–68–69–70–71–74–75–77–79–84–94.
Tuberculosis Order, 1938	2 (3).
Milk (Special Designations) Order, 1938	2–3.
Milk and Dairies (Amendment) Order, 1938	2.
Sale of Milk, Regulations, 1939	1–2–3.
Defence (General) Regulations, 1939	54B–55G–62.
Milk (Special Designations) Regulations, 1941	2.
Milk (Scheme of Supply) Order, 1941	Whole Order
Milk (Use of Churns) Order, 1941	2.
Milk (Sales to Distributors) Order, 1942	Whole Order
Milk (Special Designation) Regulations, 1942	2.
Milk (Use of Churns) Order, 1942	Whole Order
Milk and Dairies Regulations, 1943	2
Defence (Sale of Food) Regulations, 1943	3.

Act or Order	Section or Article Applying
Milk (Use of Bottles) Order, 1943 . .	2.
Milk (Special Designations) Order, 1943 .	2.
Heat-treated Milk (Prescribed Tests) Order, 1944	Whole Order
Food and Drugs (Milk and Dairies) Act, 1944	1-2-3-4-5-6-7-8-9.
Milk (Special Designations) Regulations, 1946	Whole Order

DETAILS OF EXISTING LEGISLATION

All superfluous matter has been omitted from the following paragraphs only such Acts, Orders or Sections or parts thereof as deal strictly with the control of milk supplies have been indicated. *A cross index is embodied on the general index at the conclusion of the volume for the use of those desirous of obtaining details of any legislation governing a particular aspect of the milk problem.*

Public Health (Prevention of Tuberculosis) Regulations, 1925

Definitions : " Milk " means milk (including cream, skimmed milk and separated milk) intended for sale for human consumption.

" Dairy " includes any farm, cowshed, milk store, milk shop, or other place from which milk is supplied on, or for, sale, but does not include a shop or other place in which milk is sold for consumption on the premises only.

Employment of Persons Suffering from Tuberculosis. Article 4. No person who is aware that he is suffering from tuberculosis of the respiratory tract shall enter upon any employment or occupation in connection with a dairy which would involve the milking of cows, the treatment of milk, or the handling of vessels used for containing milk.

Stoppage of Employment. Article 5. Notwithstanding anything contained in the Public Health (Tuberculosis) Regulations, 1912, if a local authority on the report in writing of their medical officer of health are satisfied that a person residing in their district who is engaged in any such employment or occupation as aforesaid is suffering from tuberculosis of the respiratory tract and is in an infectious state, they may by notice in writing signed by the clerk or the medical officer of health require such person to discontinue his employment or occupation on or before the day specified in the notice, such date being not less than seven days after the service of the said notice, and such person shall thereupon comply with the said notice.

A copy of the notice in the required form will be found in Appendix I, page 460.

Right of Appeal. Article 6. Allows a person right of appeal to a Court of Summary Jurisdiction.

Compensation. Article 7. The provisions of Section 308 of the Public Health Act, 1875 (which relates to compensation for damages sustained by reason of the exercise of the powers of the Act) shall apply to any person who sustains any damage by reason of the exercise of any of the powers of these regulations in relation to any matter as to which he is not himself in default.

Milk and Dairies Order, 1926

This Order was made under Acts now repealed but its operation is continued by the Food and Drugs Act, 1938. In many respects, the provisions are not sufficiently comprehensive while some clauses are so indefinite as to allow of a wide difference of opinion as to their requirements. Consequently, any appeal to the courts is a matter of conjecture.

Definitions : " Infectious disease " means any infectious disease to which the interpretation in Section 343 of the Public Health Act, 1936, applies.

" Cowkeeper " means any person who keeps one or more cows for the purpose of the supply of milk.

"Milk" means milk intended for sale for human consumption or for use in the manufacture of products for sale for human consumption, and includes cream, skimmed milk and separated milk.

Note the reference in this definition to the word "sale" which has the effect of limiting the application of most of the provisions of the Order.

"Dairy" includes any farm, cowshed, milk store, milk shop or other place from which milk is supplied on or for sale, or in which milk is kept or used for purposes of sale or manufacture into butter, cheese, dried milk or condensed milk for sale, and, in the case of a purveyor of milk who does not occupy any premises for the sale of milk, includes the place where he keeps the vessels used by him for the sale of milk, but does not include a shop from which milk is not supplied otherwise than in properly closed and unopened receptacles in which it was delivered to the shop or a shop or other place in which milk is sold for consumption on the premises only.

"Registered premises" means any building or other premises required to be registered under the provisions of this order.

Duty of Owner to Make Terms of Order Known to Employees. Article 4. Every cowkeeper and dairyman shall take all practicable steps to make the provisions of this order known to every person in or about any registered premises in his occupation so far as such provisions impose any duties or restrictions on such person and so far as they relate to the processes carried out by such person.

Keeping of Registers. Article 6. (1) Every sanitary authority shall keep registers of all persons carrying on in their district the trade of cowkeeper or dairyman and of all farms and other premises within their district which are used as dairies.

When the Food and Drugs (Milk and Dairies) Act, 1944 comes into operation registration of producers will be transferred to the Minister of Agriculture and this Article should now be read in the light of such alteration.

It should be noted that all retail purveyors of milk must be registered whether or not they occupy premises in the area of the registering Authority. Cowkeepers and dairymen having premises in a district but whose milk is sold outside the district must also be registered. Persons keeping milking cows and producing milk for their own use do not require to be registered. No local authority can refuse to register persons, other than retail purveyors, who carry on the trade of cowkeeper or dairyman or use any premises as dairies. Shops selling milk in sealed bottles have to be registered as "retail purveyors of milk."

(2) Subject to the provisions of any other statutory enactment, the sanitary authority, on the application of any person proposing to carry on in their district the trade of cowkeeper or dairyman or to use any farm or other premises in the district as a dairy, shall register such person or such premises.

(3) Subject as aforesaid no person shall carry on the trade of cowkeeper or dairyman or use any premises as a dairy unless he and any such premises are registered in pursuance of this article.

(4) The sanitary authority shall immediately after the commencement of this order inform the county council of the particulars of registration then in force of cowkeepers and their premises, and they shall as soon as may be inform the county council of all alterations made in the registers.

Two registers are usually kept, one for recording cowkeepers and wholesale purveyors and one for retail purveyors. Specimens of the necessary forms and registers will be found in Appendix I, pages 461 to 465.

Notice of Use of New Building. Article 7. Before commencing to use as a cowshed or as a place for keeping of milk a building not previously used for that purpose, the occupier shall give one month's notice in writing to the sanitary authority of his intention to do so.

Articles 8, 9 and 10 have been repealed by Article 3 of the Milk and Dairies Amendment Order, 1938. This step was rendered necessary by the transfer of the functions of veterinary inspection from Local Authorities to the Minister of Agriculture and Fisheries under Section 19 (1) of the Agriculture Act, 1937.

Health of Animals. Article 11. The following diseases affecting cows, now set out in the First Schedule, Part I, of the Food and Drugs Act, 1938, shall be diseases for the purpose of this Article. These are :

Acute mastitis ;
Actinomycosis of the udder ;
Suppuration of the udder ;
Any infection of the udder or teats which is likely to convey disease ;
Any comatose condition ;
Any septic condition of the uterus ;
Anthrax ;
Foot and Mouth disease ;

Provided that, where an officer of a local authority gives a notice under the section with regard to any of the diseases set out in this article :

(1) The notice shall forthwith be withdrawn as soon as the officer or the authority is satisfied that the cow is no longer in an infective condition ; and it shall in any case cease to operate at the expiration of such period not exceeding five days as may be specified therein, but without prejudice to the right of the officer to give a further notice or notices with a like limitation of duration ; and

(2) The local authority shall, if required so to do by the person receiving such notice, afford him an opportunity to appear before them for the purpose of applying for the withdrawal of the notice and shall consider any written representations made by him for the same purpose.

General Provisions for Securing the Cleanliness of Dairies, etc., and for the Protecting of Milk against Infection and Contamination

This Section of the Order deals with structural alterations and the onus of executing such works as may be necessary falls on the occupier and not the owner. From one point of view, this is an inherent weakness as in many cases it is almost impossible to have any extensive structural alterations carried out so long as the law exempts the owner of the property. On the other hand, the cowkeeper is carrying on a business for personal gain and not for the owner's benefit, and, for such business, suitable premises are necessary. It may be reasonably argued, therefore, that it is quite right for responsibility of improvements to rest on the producer's shoulders. Many owners are quite willing to carry out necessary alterations or improvements provided the tenant will pay interest on money so expended.

The Order is particularly indefinite with regard to premises and although clean milk may, by means of considerable effort, be produced in poor premises, obviously better results are more easily obtained in properly constructed buildings which are more readily cleansed. One interesting omission in the Order is that it does not mention provision of a cowshed but merely infers that one already exists and certain indefinite standards for the building are prescribed. If the producer does not wish to provide a cowshed, and in some parts of this country many do not, there is no power given to prevent milking in any open yard or in fields. Provided he does not use a building for milking purposes when it would become a cowshed, the producer's only liability is to carry out the milking process where there is no danger of contamination.

Windows and Lighting. Article 12. (1) Every cowshed and every building used for keeping milk, other than a cold store, shall be provided with a sufficient number of windows or other openings suitably placed and communicating directly with the external air. The windows or permanent openings shall be such as to secure that the building is sufficiently lighted during the hours of daylight and the openings provided for ventilation shall be kept in proper order and so used as to secure that the air in the building is kept in a fresh and wholesome condition.

A serious omission is the absence of any definite standard of window space in relation to the floor area, while no minimum area for ventilation openings is prescribed.

Lighting (*Artificial*)—(2) Every such building in which milking or any other process is carried on during the hours of darkness shall also be provided with such lamps or other means of artificial lighting as will enable any such process to be conducted in good and proper light.

Water Supply. Article 13. (1) All registered premises shall be provided with a supply of water suitable and sufficient for the requirements of this order.

The word "suitable" is indefinite and liable to lead to arguments as to the suitability of a particular supply. The Order should have required a pure, wholesome and sufficient supply.

Cleansing of Receptacles. (2) Every receptacle used for the storage or conveyance of water shall be emptied and cleansed from time to time as often as may be necessary to prevent the pollution of the water and to maintain it in a suitable condition for the purpose for which it is required.

Prevention of Contamination of Water Supply. (3) The water supply used for the watering of cows shall, as far as reasonably possible, be protected against contamination caused by the drainage of foul water.

Attention is drawn to the phrase "as far as reasonably possible," and to the fact that provision is not made to guard against *every* kind of contamination. No mention is made of a *pure* water supply, and the wording allows too much latitude in respect of water supplies generally.

Storage of Milk. Article 14. (1) Milk shall not be deposited or kept in any place where it is liable to become contaminated or infected. In particular it shall not be deposited or kept :

(i) In any room used as a kitchen, scullery, living-room or sleeping-room ; or

(ii) In any room or part of a building which communicates directly by door, window or otherwise with :

- (*a*) Any water closet, earth closet, privy, cesspool or receptacle for ashes or other refuse ; or
- (*b*) Any room which is used as a sleeping-room or any room which is occupied by a person suffering from an infectious disease, or which having been so occupied, has not been subsequently properly disinfected ; or

(iii) In any room or part of a building in which there is any direct inlet to a drain which is not sufficiently trapped ;

Provided that the foregoing provisions shall not be deemed to prohibit the deposit or keeping of milk intended for use in the manufacture of butter, cream, or cheese in a room used as a kitchen.

(2) Vessels containing milk shall be properly covered, or the milk shall be otherwise effectively protected from dust, dirt, flies, or other sources of contamination ;

(3) No foul or noxious matter or soiled bed or body clothing shall be conveyed through any part of a building used for the keeping or storage of milk.

No mention is made of any gas, vapour, effluvia or other odoriferous articles likely to taint milk.

It should be noted that this Article permits the storage of milk in a room entered directly from a living-room. In this respect, it is difficult to decide when a room ceases to be a living room and becomes a kitchen or, when a kitchen is not a scullery.

Cleanliness of Milkers. Article 15. Persons milking cows, distributing or handling milk must keep their persons and clothing in a cleanly condition.

It would not seem unreasonable if, as an added precaution, this Article had required milkers to wear washable caps and overalls.

Duty of Carrying Out Processes Free from Danger of Contamination. Article 16. No person shall carry out the processes of cooling, bottling, sterilising or pasteurising milk or any other process connected with milk, or keep any appliances used in such processes in any cowshed or in any place where contamination may arise from cowshed, stable, or manure heap.

Notification of Infectious Disease Occurring in Family of Milker. Article 17. (1) Every person having access to the milk or to the churns or other milk receptacles in or about any registered premises, as soon as he becomes aware that any member of his household is suffering from an infectious disease, shall immediately notify the occupier of such premises of the fact, and the occupier shall immediately notify the medical officer of health of the district in which the premises are situate unless notification has already been given to that officer.

Duty of Sanitary Authority to Notify Adjoining Authority. (2) Where the medical officer of health of any sanitary district becomes aware that any such person is suffering from an infectious disease or has recently been in contact with a person so suffering, he shall forthwith notify the occupier of such premises of the fact, and where the council of such sanitary district are not the registering authority for the locality in which the premises are situate, he shall also notify the medical officer of health of the registering authority.

Stoppage of Milk Supply following Cases of Infectious Disease. Article 18. (1) Empowers the medical officer possessing evidence that any person is suffering from any infectious disease caused by the consumption of milk, supplied within the district from any registered premises, or that the milk at any registered premises has been infected with such disease, he may give notice in writing to the occupier of such premises specifying the evidence and require that no milk from such premises or that milk from a specified source shall be sold for human consumption or used for manufacturing purposes. If the premises are outside his district, notice may be given that no milk from such premises shall be sold within the district.

Period of Notice. (2) Notice operates for a period of not more than twenty-four hours, and may be renewed as required for similar periods. Notice is withdrawn when medical officer is satisfied that no further cases of infectious disease are likely to be caused by the milk supply.

Duties of Medical Officer of Health. (3) Medical officer must report service of any notice to the sanitary authority, and if premises are within his district, must endeavour to ascertain the causes of the infectious condition of the milk.

(4) If the milk is obtained from outside his district, the medical officer must serve a copy of the notice on the medical officer of the district in which the premises are registered.

Offence. (5) Makes it an offence to sell milk for human consumption or for manufacturing purposes contrary to the terms of the notice previously mentioned.

Compensation. (6) Provides for compensation for loss or damage sustained owing to such a notice.

Examination of Cases and Contacts. Article 19. (1) If a medical officer of a registering authority receives a notice as mentioned above, or otherwise suspects that any person employed at registered premises and handling milk or utensils in any manner is suffering from an infectious disease or has been in contact with an infected person or is in such a condition that infection is likely to be spread, he may give notice to the occupier of the premises that he intends to make an examination of all or any of such persons. Facilities have to be provided by the occupier for making such an examination.

Stoppage of Employment. (2) If, after the examination, the medical officer considers that the employment of any person is likely to lead to the spread of infectious disease, he may give notice to the occupier and to the person concerned requiring that, for a specified period, the person must not milk cows, or handle milk or utensils in any manner.

(3) A person to whom the notice relates or any other person suffering from an infectious disease or who has been in contact with an infected person shall not milk cows or handle milk or utensils until the period mentioned in the notice has expired, or until the danger of the spread of disease by milk has ceased.

(4) No cowkeeper or dairyman shall allow any person to which a notice relates or any other person as previously mentioned to handle milk or milk cows or take part in the production or distribution of milk until the period mentioned in the notice expires or until the danger of the spread of disease by milk has ceased.

Keeping of Pigs, Poultry, etc., in Dairy. Article 20. No person shall keep pigs or poultry in any cowshed or dairy or in any room adjoining same.

Article 21 has now been repealed and amended by the Milk and Dairies Regulations, 1943. The Article, as altered, is set out on page 437.

Cleanliness of Cowshed. Article 22. (1) Every part of the interior of cowshed must be thoroughly cleansed as often as may be necessary.

The words " as often as may be necessary " permit of fairly wide interpretation.

(2) Ceiling or interior of roof and walls must be properly limewashed or otherwise disinfected at least twice a year, once during April or May, and once during September and October and at such other times as may be necessary. Ceiling or walls properly painted or varnished or constructed or covered with tiles or other washable material must be washed down from time to time to keep it clean.

(3) Dung or other offensive matter must be removed from the cowshed at least once a day.

The removal of dung once daily does not infer a particularly high standard of cleanliness. An enactment making it compulsory for dung to be removed twice daily would have been more satisfactory.

(4) Dung or offensive matter must not be placed so as to render uncleanly the access to any cowshed or dairy.

It is possible to place the dung against the wall of the cowshed without fouling the access to the building, or to the dairy. A specified distance at which manure should be placed ought to have been included.

Milking of Cows. Article 23. The following precautions shall be taken by every cowkeeper in connection with the milking of cows :

(1) Milking to be carried out in a good and proper light whether in daytime or during hours of darkness.

(2) Before milking commences, all dirt around flanks, udder or teats of each cow to be removed and udder and teats cleansed by rubbing with a clean damp cloth.

(3) The hands of the milker to be thoroughly washed and dried before milking commences, and throughout milking operations shall be kept clean and dry.

No mention is made of the essential provision of accessible washing accommodation.

Milking Stools. (4) All milking stools must be kept thoroughly clean.

No mention is made of the storage of milking stools in a clean place.

Removal of Milk. (5) Milk from each cow must be removed as soon as possible from cowshed to a suitable milk room after milking or placed in a covered receptacle.

The phrase " as soon as possible " should be deleted and the word " immediately " substituted.

Bedding. (6) No dry bedding or other dusty matter must be moved in the cowshed during milking or within half an hour before milking commences, except so far as may be necessary for the removal of dung.

It would have been more satisfactory if the words "except so far as may be necessary for the removal of dung" had been omitted.

Cooling of Milk. Article 24. (1) Every cowkeeper shall, without any delay other than that caused by any process of straining or centrifugalisation to which it may be subjected, cause the milk to be cooled to a temperature of not more than 5° F. higher than the temperature of the cooling water. Except :

(i) When the milk is delivered without delay to a collecting station provided with facilities for cooling milk to a temperature not exceeding 55° F.

(ii) When milk is to be used for manufacturing purposes at the place of production or is supplied to some other person for this purpose.

(iii) When the cowkeeper sells the milk to the consumer and delivers it at least twice a day on the day of production.

(iv) When the cowkeeper sells the milk to a retailer for delivery to the consumer immediately after milking.

(2) Uncooled milk received at a collecting station to be cooled to a temperature not exceeding 55° F. Dairyman receiving uncooled milk must, unless he delivers same immediately to customers, cool it down to a temperature of 55° F.

It will be observed that no definite temperature is prescribed to which the cowkeeper should cool milk. This is a serious omission, as the temperature of cooling water available at farms may vary within wide limits. It would have been more satisfactory if the Article had stated that *all* milk must be cooled immediately after production to a specified temperature, and also that milk should be cooled at a collecting station or when received by the distributor, irrespective of any previous cooling.

Construction of Floor and Standings of Cowshed. Article 25. Every cowkeeper shall cause the floor of every cowshed in his occupation to be constructed of such material and in such manner as to render it practicable to remove all liquid matter which may fall thereon, and he shall cause such cowshed to be provided with channels of rendered concrete or other durable and impervious material so constructed as to prevent as far as reasonably practicable the soiling of the cows and so as to receive all such liquid matter and to convey it to a suitable drain or other place of disposal outside such cowshed.

PROVISIONS AS TO BUILDINGS USED FOR THE SALE OF MILK

Furniture and Fittings. Article 26. (1) The furniture and fittings must be cleansed thoroughly as often as necessary, and the floor must be cleansed with water at least once a day.

Floor. (2) Except in the case of a building or part of a building which is used for the sale of milk by retail, the floor must be constructed of rendered concrete or other durable or impervious material and so sloped as to ensure the removal of all liquid matter which may fall thereon, and be provided with channels to carry off all liquid matter to a suitable drain outside the building.

The Order is decidedly inadequate and indefinite regarding the provision of a dairy or milkroom. While certain conditions as to lighting, ventilation, floors, etc., are prescribed, no mention is made of separate storage room apart from the washing room.

CONVEYANCE AND DISTRIBUTION OF MILK

Capability of Receptacles to be Readily Cleansed. Article 27. No churn, vessel, or receptacle shall be used for the reception, measurement, storage, or delivery of milk unless the interior surface is capable of being readily cleansed.

Cleansing of Churns. Article 28. Any person purchasing milk must thoroughly cleanse and securely close all churns and receptacles other than bottles in which he receives milk before they leave his custody or control, for return to the owner.

Churns must be thoroughly cleansed by the distributor before they are returned to the producer. Many churns are received back at the point of production in an extremely dirty condition. Carriers are not always over-particular in their methods of handling these vessels, pushing the empty churns off the lorry on to the side of the road regardless of mud and other filth into which they may fall. Although producers are required to ensure that churns are clean before they are filled, this is surely no reason why there should be any unnecessary re-contamination.

Labelling and Sealing of Churns. Article 29. Every churn, vessel, or other receptacle, other than bottles, in which milk is despatched by road or rail, shall :

(1) Have the name and address of the owner permanently marked on such vessels or on metal plates securely fixed or soldered thereto.

(2) The lids of churns and other receptacles to be so constructed and fitted as to prevent the access to the milk of dirt, dust or rainwater, or the return to interior of the receptacle of any milk which may have been splashed above the lid.

Labelling of Churns (*Skimmed Milk, etc.*). Article 30. All churns and other receptacles containing skimmed or separated milk have to be labelled in large and legible type " Skimmed Milk " or " Separated Milk."

Opening of Churns. Article 31. (1) Except in pursuance of any statutory authority in that behalf, no person shall open any churn, vessel, or other receptacle containing milk or transfer milk from one receptacle to another in any railway van or on any railway station :

Provided that this article shall not be deemed to prohibit the purchaser or his agent when taking delivery of the milk from opening a churn, vessel or other receptacle containing milk or transferring the milk to another receptacle so far as such opening or transfer may be necessary for the purpose of checking and sampling the milk.

Bottles. (2) Where a person delivers milk in bottles he shall cause every such bottle to be filled and closed on registered premises ; and no person shall remove or tamper with the disc or other device used for closing the bottles at any time after it has left such premises and before it is delivered to the consumer.

Prevention of Contamination. Article 32. Persons engaged in the conveyance or distribution of milk must take precautions to prevent the exposure of milk to heat and from being contaminated by dirt, dust or rainwater.

No provision is made for preventing the contamination of milk by storage in proximity to any odoriferous matter.

Vehicles. Article 33. The interior of any vehicles used for the conveyance of milk must be kept clean. No live animal or any article likely to contaminate milk must be conveyed in the vehicle at the same time as milk, and no vehicle which has been used for the conveyance of offensive matter shall be used for the conveyance of milk until it has been thoroughly cleansed and purified.

This Article applies to railway vehicles. Note that " live animal " only is mentioned. The Article does not cover dead animals or dressed carcases.

Public Health (Imported Milk) Regulations, 1926

Definitions : " Imported Milk " means any milk imported into England and Wales from any place situated outside the British Islands.

These Regulations require the registration by Port and Riparian Sanitary Authorities of persons receiving imported milk, and give power to register or remove from a register such persons if the Regulations are not complied with. Imported milk has to fulfil the following requirements :

(1) Must not contain more than 100,000 bacteria per ml. when a sample is taken.

(2) Must be free from tubercle bacilli.

Imported milk, by reason of the distance it has to travel, is generally pasteurised, and the above requirements, given efficient pasteurisation, should be easy of attainment.

Before the war, liquid milk was imported in large quantities from Holland and Denmark.

Public Health (Infectious Disease) Regulations, 1927

Under these Regulations, any person suffering from typhoid fever, paratyphoid fever or dysentery, or any " carrier " of such diseases may be excluded from any occupation connected with the preparation or handling of food and drink.

Milk Act, 1934

Section 9 provides for payments to be made for securing a pure milk supply. *The Accredited Milk and Attested Herd Schemes were authorised by this Section.* Powers are also given to the Milk Marketing Board to operate schemes for increasing the demand for milk resulting in the inauguration of the Milk-in-Schools scheme.

Public Health Act, 1936

Definitions : " Premises " includes messuages, buildings, lands, easements and hereditaments of any tenure.

" Notifiable Disease " means any of the following diseases, namely, small-pox, cholera, diphtheria, membraneous croup, erysipelas, scarlet fever, typhus fever, typhoid, and enteric fevers.

Removal of Noxious Matter. Section 79. (1) Any borough or urban district or any rural district in which Section 49 of the Act of 1875 was in force immediately prior to the commencement of this Act may, through their Sanitary Inspector, order the removal of any noxious matter by serving notice on the owner or on the occupier of the premises on which it is found and if the notice is not complied with within twenty-four hours, the inspector may remove the matter referred to.

(2) Local authority may recover expenses incurred in so doing.

It is not necessary for the Sanitary Inspector to obtain authority from his Council before serving a notice under this Section which, if properly applied, ensures prompt removal of offensive matter, such as manure, from the immediate vicinity of a cowshed or dairy.

Section 80. (1) In the districts specified in the previous Section, the local authority may, by public notice, require the periodical removal of manure from mews, stables or other premises at such intervals as may be specified.

(2) Provides penalty.

It will be observed that cowsheds or dairies are not specifically mentioned in this Section but a notice under its provisions may be served for the periodical removal of manure from such premises.

Section 149. Any person knowing that he is suffering from a notifiable disease, engages in or carries on any trade, business or occupation in which he cannot engage in or carry on without risk of spreading the disease shall be liable to a fine not exceeding five pounds.

Public Health (London) Act, 1936

Definitions : " Cattle " includes sheep, goats and swine.

" Dairy " includes any farm, farmhouse, cowshed, milk store, milk shop, or other place from which milk is supplied or in which milk is kept for the purposes of sale.

" Dairyman " includes any cowkeeper, purveyor of milk or occupier of a dairy.

Removal of Manure. Section 93. (1) Where it appears to a sanitary inspector that any accumulation of any obnoxious matter, whether manure, dung, soil, filth, or other matter, ought to be removed, and it is not the duty of the sanitary authority to remove same, he shall serve notice on the owner thereof or on the occupier of the premises on which it exists, requiring him to remove the same, and if the notice is not complied with within forty-eight hours from the service thereof, exclusive of Sundays and public holidays, the matter referred to shall be the property of the sanitary authority, and be removed and disposed of by them, and the proceeds (if any) of such disposal shall be applied in payment of the expenses incurred with reference to the matter removed and the surplus (if any) shall be paid on demand to the former owner of the matter.

(2) The expenses of such removal and disposal, so far as not covered by such proceeds, may be recovered by the sanitary authority in a summary manner from the former owner of the matter removed, or from the occupier, or, where there is no occupier, the owner of the premises.

It is not necessary for the Sanitary Inspector to obtain authority from his Council to serve notice under this section.

Section 94. (1) A sanitary authority may collect and remove manure and other refuse from any stable or cowhouse within the district, the occupier of which signifies his consent thereto in writing.

(2) The sanitary authority, if they think fit, may employ a sufficient number of scavengers, or contract with any scavengers, whether a company or individuals, for collecting and removing the manure and other refuse matter from any . . . cowhouses within their district, the occupiers of which signify their consent in writing to such removal, provided that,

(*a*) such consent shall not be withdrawn or revoked without one month's previous notice to the sanitary authority ; and

(*b*) no person shall be hereby relieved from any fine to which he may be subject for placing dung or manure upon any footways or carriageways, or for having any accumulation or deposit of manure or other refuse matter so as to be a nuisance or injurious or dangerous to health.

Notice may be given by a sanitary authority (by public announcement in the district or otherwise) requiring the periodical removal of manure or other refuse matter from . . . cowhouses . . . and, where any such notice has been given, if any persons to whom the manure or other refuse matter belongs fails to comply with the notice, he shall be liable without further notice to a fine not exceeding twenty shillings for each day during which such non-compliance continues.

Licensing of Premises. Section 144. (1) Cowhouses not to be used unless licensed by Borough Council. Fine for so doing not to exceed £5. If cattle are taken into unlicensed premises, it shall be *prima facie* evidence that an offence under this Section has been committed.

(2) Provides for yearly licence as directed by issuing Council and for licence fee not exceeding 5*s*.

Milk (Special Designations) Order, 1936

This Order revokes the Orders of 1923 and 1934. The Milk (Special Designations) Order, 1938, amends certain definitions and Articles in the principal Order and these alterations have been incorporated in the text of the Articles which follow :

Definitions : " The Minister " means the Minister of Health.

" Licensing authority " means, in relation to any application for the grant of a licence, the authority which has power under this Order to grant the licence, and in relation to any licence which has been granted means the authority by which the licence was granted.

" Area " means the area of the licensing authority.

" Supplementary licence " means a licence authorising the use of a special designation in relation to milk sold by retail in an area other than that comprising the establishment from which it is sold.

" Milch cow " means a cow kept for milking purposes.

" Herd " means the milch cows kept in respect of which any licence is applied for or granted, as the case may be and includes any other bovine animal for the time being kept in contact with such cows.

" Attested herd " means a herd on the Register of Attested Herds kept in pursuance of arrangements made under Section 9 of the Milk Act, 1934, or of a scheme made under Section 20, of the Agriculture Act, 1937.

" Sell " includes offer or expose for sale.

" Sale " shall be construed accordingly.

" Dealer " means any person who sells milk either by wholesale or by retail, and a person to whom the milk is delivered to be used in any manufacturing process.

" Producer " means a person owning or having control of a herd from which milk is obtained.

" Examination " of an animal means a clinical examination carried out in such a manner as the Minister may direct by a private veterinary surgeon, or made by an inspector.

" Veterinary Surgeon's Certificate " means a certificate in a form directed by the Minister, signed by the private veterinary surgeon who has made such examination and certifying the result thereof.

" Tuberculin test " of an animal means a test made with such tuberculin and in such manner as the Minister may direct, by a veterinary surgeon, or by an inspector.

" Certificate of tuberculin test " means a certificate in a form directed by the Minister, signed by the private veterinary surgeon making the test and certifying the result thereof, the animal to be identified in the certificate by its identification mark.

" Sample " means a sample taken by a person duly authorised in that behalf by the licensing authority.

The following are new definitions :

" Consumer " means any person, not being a dealer, to whom the milk is delivered.

" Inspector " means a veterinary inspector appointed by the Minister of Agriculture and Fisheries.

" Private veterinary surgeon " means a veterinary surgeon approved by the licensing authority.

Specified Grades. Article 3. Specifies the designations under which milk is permitted to be sold. (These have already been set out on page 239).

Licensing Authorities. Article 4. (1) Sets out the local authorities who are empowered to grant licences and details the type of licence each authority is allowed to issue.

By reason of the large and increasing number of licences now issued annually, the task of licensing was delegated to local authorities in all cases. Such authorities are not authorised to grant licences to themselves if they are producers of graded milks ; these licences are still granted by the Minister of Health. When the Food and Drugs (Milk and Dairies) Act, 1944 comes into operation, all licences for production of raw designated milks will be granted by the Minister of Agriculture and Fisheries and this and succeeding Articles should be read with such alteration in mind.

Granting of Licences. (2) A licence, other than a licence granted by the Minister, shall authorise the use of a special designation only in relation to milk sold at or from the establishment mentioned in the licence and (except in the case of milk sold by wholesale) only within the area of the licensing authority. Provided that a licence (other than a supplementary licence) in relation to milk sold at or from a pasteurising establishment shall apply also in relation to milk pasteurised at that establishment and sold by the holder of the licence at or from any other establishment in the same area.

(3) Where the holder of a licence authorising him to use a special designation in relation to milk sold by him at or from an establishment in one area proposes to sell the milk by retail in another area, the licensing authority of the second area may grant him a supplementary licence authorising him during the period of operation of the first mentioned licence to use the special designation in relation to milk so sold in their area, but in that event nothing in this Order shall authorise that authority, either before the grant or during the period of operation of the supplementary licence to exercise any powers under this Order outside their area.

Article 5. (1) Every licence granted must be drafted in the form set out in the First Schedule of the Order, modified as the circumstances may require.

(2) All licences granted for one year or part of a year, ending on the 31st December for the year in which it was granted.

Article 6. (1) Application for a licence to be made in writing.

(2) Where a person applies for a licence (other than a renewal of an existing licence) in respect of an establishment other than that at which the milk is produced or in the case of a licence to use the special designation "Pasteurised" that at which the milk is pasteurised he shall state the name and address of the licensed dealer from whom he proposes to obtain the milk.

(3) Where a producer applies for a licence (otherwise than in renewal of an existing licence) to use the special designation "Tuberculin Tested" he shall either satisfy the licensing authority that the herd in respect of which the licence is applied for is an attested herd or that every animal in the herd at the date of application has, not more than one month before the date of such application been the subject of a tuberculin test made by an inspector or furnish the authority with a certificate of a tuberculin test of every animal in the herd at the date of the application made not more than one month before the date of such application. He shall also either satisfy the authority that every animal in the herd at the date of the application has, not more than one month before the date of such application, been the subject of an examination made by an inspector, or furnish the authority with a veterinary surgeon's certificate of an examination of every animal in the herd at the date of application made not more than one month before the date of such application.

He shall satisfy the authority that every animal which has been certified as reacting to the tuberculin test has been removed from the herd and that any animal certified as showing evidence of any disease which is likely to affect milk injuriously has been segregated from the rest of the herd or removed from the herd as the case may require.

(4) This sub-section repeats the last two paragraphs in connection with Accredited milk.

(5) Every person who applies for a licence shall satisfy the licensing authority that his arrangements for the production, storage, treatment and distribution of milk are such as to comply with the conditions subject to which the licence may be granted.

Article 7. (1) States that every licence granted under this Order is subject to the general conditions set out in the Second Schedule of the Order.

(2) States that the conditions set out in Parts 1, 2 or 3 of the Third Schedule of the Order shall apply to the particular grade of milk therein specified.

(3) Unless the licensing authority agree, all the examinations and tuberculin tests prescribed in the Third Schedule for animals in a herd shall be made by an inspector.

For specimen forms of licence, see Appendix I, pages 458 to 460. The general conditions subject to which licences may be granted, mentioned above, are set out on pages 239 to 240, while the special conditions applying to each grade of milk will be found on pages 240 to 243. These have been amended in accordance with the changes specified in the Amendment Order of 1938.

Fees. Article 8. This lays down the maximum fees payable for the different types of licences and has already been set out on pages 245 to 246.

Revocation of Licences. Article 9. (1) Gives power to revoke licences if conditions of licence are not complied with, after the holder of such licence has been informed of the grounds on which it is proposed to revoke the licence, and after the holder has been afforded the opportunity of making any representations he may think fit. Licence cannot be revoked when the milk is found not to comply with the conditions of the licence if the holder of such licence can prove that the milk had left his control and that such non-compliance was not due to himself, his servants or agents.

(2) Any person aggrieved by the decision of a Licensing Authority to refuse, suspend or revoke a licence may, after receiving notice of such decision, within seven days, appeal to the Minister of Health, whose decision is final.

(3) Any decision to suspend a licence shall not have effect until seven days have elapsed after notice of such decision. In the case of an appeal, the licence shall remain in force until the end of the year in respect of which it was granted or until the appeal is determined, whichever is the earlier.

(4) If any application for the renewal of a licence is refused, the existing licence shall remain in force for seven days after refusal or if an appeal is made, until the determination of the appeal.

Applicability of Licences. Article 10. (1) The holder of a licence to use the special designation "Tuberculin Tested" may also use the designation "Accredited" in relation to milk to which that licence applies.

(2) Milk produced under special designation in Scotland may be sold under a similar designation in England and Wales.

This Article permits a producer of Tuberculin Tested milk to sell milk which is surplus to his normal retail requirements as Accredited milk at a lower price.

Agriculture Act, 1937

Section 19. (1) This Section transfers the powers of veterinary inspection from local authorities to the Minister of Agriculture and Fisheries.

Section 20. States that the Minister of Agriculture and Fisheries may make payments to the owners of any herds of cattle in Great Britain for securing that their herds are free from tuberculosis.

This latter section has now been extended by Section 4 of the Agriculture (Miscellaneous War Provisions) (No. 2) Act, 1940 to expire on September 30th, 1948.

Food and Drugs Act, 1938

Definitions: "Authorised Officer" means in respect of any council, an officer of the council authorised by them in writing, either specially or generally, in regard to taking of samples under the Act. The medical officer of health and sanitary inspector of any council shall, by virtue of their office, deemed to be authorised officers for the purposes of the Act.

"Dairy" includes any farm, cowshed, milk store, milk shop or other premises from which milk is supplied on or for sale, or in which milk is kept or used for purposes of sale or in which vessels used for the sale of milk are kept. Does not include any shop where milk is consumed on the premises or to which milk is delivered and supplied in properly closed and unopened receptacles.

"Dairyman" includes an occupier of a dairy, a cowkeeper, and a purveyor of milk.

"Food" means any article used as food or drink for human consumption.

"Milk and Dairies Regulations" means Regulations made by the Minister for the purposes set out in Section 20 of the Act.

"Officer" includes servant.

"Premises" includes messuages, buildings, land, easements and hereditaments of any tenure.

"Purveyor" in relation to milk, includes any person who sells milk, either wholesale or by retail.

"Transit" includes all stages of transit from the dairy, place of manufacture or other source of origin to the consumer.

"Vessel" includes a receptacle of any kind, whether open or closed.

Alteration of Article. Section 1. Prohibits the addition of any substance to food so as to render it injurious to health.

Section 2. Prohibits the abstraction of anything from an article of food so as to affect injuriously the nature, substance or quality of the article.

Sale of Article. Section 3. Provides that no person shall sell to the prejudice of the purchaser any article of food . . . which is not of the nature, substance or quality demanded by the purchaser.

Milk and Dairies Regulations. Section 20. Gives to the Minister of Health and the Minister of Agriculture and Fisheries jointly the power to make regulations for any or all of the following purposes:

(*a*) For the registration of dairymen and dairies and for prohibiting any person carrying on such trade unless both he and the premises are registered.

(*b*) For the inspection of dairies and of persons about dairies who have access either to milk or any milk containers.

Passages (*a*) and (*b*) above have now been amended by the Food and Drugs (Milk and Dairies) Act, 1944, see pages 439 to 441.

(*c*) Regarding lighting, ventilation, cleansing, drainage and water supply of dairies.

(*d*) For securing cleanliness of churns and other milk vessels and appliances.

(*e*) For prescribing precautions to be taken for protecting milk against infection and contamination.

(*f*) For preventing danger to health from the sale of infected, contaminated and dirty milk and for prohibiting the sale of milk suspected of being infected.

(*g*) Imposing obligations on dairymen and their employees in regard to cases of infectious disease.

(*h*) Regulating cooling, conveyance and distribution of milk.

This paragraph has now been amended by the Food and Drugs (Milk and Dairies) Act, 1944, page 440.

(*i*) Regarding labelling, marking, or identification and sealing or closing of churns or other vessels used for the conveyance of milk, labelling of vessels in which milk is sold or offered or exposed for sale or delivered and display of vendor's name and address on any stall, cart, barrow or other vehicle from which milk is sold or delivered.

(*j*) Where no express provision is made in the Act for prohibiting or restricting addition or abstraction of any constituent from milk and sale of milk to which or from which such addition or abstraction has been made or which has been otherwise artificially treated.

(*k*) For preventing danger to health from the importation of milk.

No Regulations under this Section have yet been made but no doubt they may be expected in the near future. When they are issued it is to be hoped that they do not exhibit the vagueness or allow the latitude which at present exists in the Milk and Dairies Order, 1926. For the purposes of this Section, "milk" means milk intended for sale or sold for human consumption or intended for manufacture into products for sale for human consumption. The Minister has power to generally apply any Regulations made, or they may be limited to any specified area. This section has been amended by Section 1 of the Food and Drugs (Milk and Dairies) Act, 1944 (see page 439).

Use of Special Designations. Section 21. States that any Milk and Dairies Regulations may:

(1) Prescribe such designations, to be known as special designations, to milk of any description as the Minister considers appropriate.

(2) Provide for the granting of licences to producers and purveyors of milk authorising the use of special designations.

(3) Prescribe periods for which licences shall remain in force, conditions of issue and fee to be paid.

(4) Provide for suspension or revocation of such licences.

(5) Provide power of appeal against the suspension or revocation of a licence.

This Section prohibits the use of any special designation unless a licence authorising its use is held or referring to any milk not specially designated in such a manner as to suggest that :

(*a*) A licence is held authorising the use of a special designation.
(*b*) That the milk is tested, graded or approved by a competent person.
(*c*) That the cows from which the milk is derived are free from tuberculosis or other disease.

Amendments to this Section empowered by Section 2 of the Food and Drugs (Milk and Dairies) Act, 1944, will be found on page 440).

This Section has been amended by Section 3 of the Food and Drugs (Milk and Dairies) Act, 1944 and such amendments have been incorporated below.

Power to Refuse or Cancel a Registration. Section 22. (1) If it appears to an authority by whom dairymen are registered that the public health is or is likely to be endangered by any act or default of a person who has applied to be or who is so registered by the authority, being an act or default committed whether within or without the district of the authority in relation to the quality, storage or distribution of milk, they shall serve on him a notice stating the place and time, not being less than seven days after service of the notice, at which they propose to consider the matter and informing him he may attend before them together with any witnesses he may desire to call, at the time and place mentioned, to show cause why registration should be refused or his registration cancelled either generally or in respect of any specified premises.

(2) If the person on whom the notice has been served is unable to satisfy the Authority, they may either refuse to register him or cancel his registration as the case may be and shall forthwith give him notice of their decision and shall, if required by him within fourteen days of their decision, give him within forty-eight hours, a statement of the grounds on which their decision was based.

Appeal. (3) Person aggrieved may appeal to court of summary jurisdiction.

Cancellation of Registration following Conviction. (4) A court before which a person registered as a dairyman otherwise than by the Minister of Agriculture and Fisheries is convicted of any offence against this Act or under any Milk and Dairies Regulations may, in addition to any other penalty, cancel his registration.

Information as to previous Registration. (5) An authority other than the Minister of Agriculture and Fisheries, may require any person who applies for registration as a dairyman to give them, before his application is considered, information as to whether he is or has been registered as a dairyman whether by them or by the Minister of Agriculture and Fisheries or some other authority. The applicant is guilty of an offence if information supplied by him is false.

No Liability for Breach of Contract. (6) If a person's application for registration as a retail purveyor of milk is refused or if his registration is cancelled, he shall not be liable for breach of contract for the purchase of further supplies if such refusal or cancellation was due to the quality of milk supplied by the person with whom he holds the contract to take supplies.

It is important to remember that the day on which it is decided to serve a seven days' notice under (1) above must not be included in the period of the notice.

Removal of a Retailer from the Register

The course to be taken in removing a retailer from the register is generally as follows :

(1) A report is presented by the Medical Officer of Health or Sanitary Inspector drawing attention to any act or default on the part of the retailer and showing in what respect the public health is likely to be or is being endangered thereby.

(2) The Authority consider the matter and then serve notice upon the retailer as to the time and place when the matter is to be considered, informing him that he may call witnesses on his behalf. At least seven days' notice should be given.

(3) If the retailer fails to satisfy the Authority when he appears before them, they must give him notice of their decision in the matter forthwith.

(4) If required to do so by the retail purveyor within fourteen days of their decision, the Authority must, within forty-eight hours, state the grounds on which their refusal was based.

(5) The retail purveyor if aggrieved may then appeal to a Court of Summary Jurisdiction.

(6) Either the retail purveyor or the Local Authority may appeal further to a Court of Quarter Sessions.

It should be observed that the above procedure is carried out in respect of refusal to register a retail or wholesale purveyor of milk. Refusal to register or removal from the register may either be absolute or in respect of certain specified premises. This enables the Authority or Court to distinguish between cases in which the defect is one of general methods or those in which it has relation only to the suitability of particular premises or methods practised thereat.

Regulations re Adulteration of Milk. Section 23. The Minister of Agriculture and Fisheries may make regulations as to the presumptive evidence of the adulteration of milk.

The Sale of Milk Regulations, 1939 have resulted from the powers granted in the Section above and are to be found on page 434.

Certain Additions not to be made to Milk. Section 24. States that:

(*a*) No water, colouring matter, any dried or condensed milk or liquid reconstituted therefrom shall be added to milk intended for sale for human consumption.

(*b*) No unseparated milk or mixture of cream and separated milk shall be added to unseparated milk intended for such sale, or

(*c*) Sell or offer or expose for sale or have in his possession for the purposes of sale, for human consumption any milk to which such additions have been made.

(*d*) No person shall sell, offer or expose for sale as milk any liquid to which separated, dried or condensed milk has been added.

Prohibition of Sale of Tuberculous Milk, etc. Section 25. (1) No person shall sell, offer or expose for sale for human consumption, or use in the manufacture of products for sale for human consumption the milk of any cow which to his knowledge has given tuberculous milk or is suffering from emaciation due to tuberculosis or from tuberculosis of the udder or any other disease of cows to which this Section applies.

(2) In any proceedings under this Section, the defendant shall be deemed to have known that a cow had given tuberculous milk or was so suffering as aforesaid if he could with ordinary care have ascertained the fact.

The diseases of cows to which this Section applies, in addition to Tuberculosis, are those specified in Part I of the First Schedule of the Act and include any other disease which may be added by any subsequent Milk and Dairies Regulations. These are:

(1) Acute mastitis.
(2) Actinomycosis of the udder.
(3) Suppuration of the udder.
(4) Any infection of the udder or teats which is likely to convey disease.

(5) Any comatose condition.
(6) Any septic condition of the uterus.
(7) Anthrax.
(8) Foot and mouth disease.

Nos. 4, 5 and 6 above are new additions to the list originally set out in the Second Schedule of the Milk and Dairies (Consolidation) Act, 1915. It should be noted that contagious abortion is not specifically mentioned but no doubt this is meant to be dealt with under (6) above.

Section 26. Provides that a Local Authority outside London who are not a Welfare Authority may, with the approval of the Minister, establish milk depots for the sale of milk specially prepared for infant consumption and may purchase and prepare milk and provide the necessary plant.

Restrictions on Importation. Section 40 (*b*). Makes it an offence to import any adulterated or impoverished milk except in containers conspicuously marked with a name or description indicating that the milk has been so treated.

Sampling of Imported Foods. Section 41. Provides powers for sampling of imported foods by Customs Officers.

Penalties. Section 42. Provides penalties for any offence under Section 40.

Enforcement of Provisions. Section 65. Gives power of enforcement of Sections 1 to 7, 24, several other Sections which do not apply to milk, and any other Section which they are required to enforce to every Food and Drugs Authority. It is the duty of the Local Authority to enforce within their district every Section of the Act whose enforcement is not expressly imposed on some other Authority. A County Council or a Local Authority may institute proceedings under any Section of, or Regulation made under this Act whether or not they are the Authority charged with such enforcement, but have no power to institute proceedings against any person for contravening or failing to comply with Milk and Dairies Regulations in respect of a dairy farm or in respect of the registration of persons carrying on or proposing to carry on the trade of dairy farmer.

Public Analysis. Section 66. Provides for the appointment of public analysts to Food and Drugs Authorities with the approval of the Minister. Prescribes qualifications, and remuneration.

Provision of Laboratories. Section 67. Any County Council or Local Authority may provide facilities for bacteriological and other examinations of samples of food and drugs.

A Local Authority may borrow money for the purpose of this Section.

Sampling. Section 68. (1) An authorised officer of a Food and Drugs Authority or of a Local Authority which is not a Food and Drugs Authority may obtain samples for bacteriological and other examination.

(2) A sampling officer may purchase samples of any food or drug.

It should be noted that a sampling officer, under this Section *may* either purchase or take samples without purchase. It is important also that an officer should be authorised to obtain samples for bacteriological examination in order that laboratory control may be fully exercised.

(4) A sampling officer or an inspector of the Minister may take samples of milk at any dairy, or at any time during transit, or at the place of delivery to the purchaser, consignee or consumer.

An authorised officer of a County Council who are not a Food and Drugs Authority may exercise like powers.

(5) Where milk sold or exposed for sale within the area of any council is obtained from a dairy situate outside that area, the Medical Officer of Health or any other authorised officer of the council may by notice in writing to the Medical Officer of Health or other authorised officer of a Food and Drugs authority within whose area the dairy is situated, or through whose area the milk passes in transit, request him to procure samples of milk at that dairy or while it is in transit and it shall be the duty of an officer who receives such notice to procure,

as soon as is practicable, samples of the milk in question and forward the samples to the officer who gave the notice or to such person as the officer may direct and the samples so procured shall be deemed to have been obtained within the area for which the last-mentioned officer acts.

(6) An authorised officer may procure samples outside his own area if the authority of the area where the samples are to be taken does not object. Such consent is not to be unreasonably withheld.

(9) Any officer taking samples in course of transit by rail shall conform to such reasonable requirements of the railway company as to prevent any obstruction in railway working.

Special Provisions as to Milk. Section 71 (1). The provision of this Act relating to the procuration of samples of milk are subject to the provisions set out in the Third Schedule of the Act.

(2) It is a defence for any defendant charged with an offence under this Act or any Food Regulations or Milk and Dairies Regulations in respect to a sample of milk taken after it has left his possession if he can prove that the churn or other vessel containing the milk was effectively closed and sealed at the time it left his possession but had been opened before the person taking the sample had access to it.

Special Provisions as to the Sampling of Milk

(1) Where a sample of milk is procured from a purveyor of milk, he shall, if required to do so by the person by whom or on whose behalf the sample was procured, state the name and address of the seller or consignor from whom he received the milk.

(2) Within sixty hours after the sample was procured from the purveyor he may serve on the authority by whose officer it was procured, or, if it was not procured by an officer of any authority, on the Food and Drugs Authority within whose area it was procured, a notice stating the name and address of the seller or consignor from whom he received the milk and the time and place of delivery to himself of milk from a corresponding milking, and requesting the authority to take immediate steps to procure, as soon as practicable, a sample of milk from a corresponding milking in the course of transit or delivery to himself from the seller or consignor.

Provided that:

(*a*) if such a sample has been so procured since the sample in question was procured, or had been so procured within twenty-four hours prior to that sample being procured, it shall not be necessary for the authority to procure another sample in accordance with the notice: and

(*b*) the purveyor shall have no right to require that such a sample shall be procured if the milk from which the sample procured from him was taken was a mixture of milk obtained by him from more than one person.

(3) If the purveyor has served on the authority such a notice as aforesaid, and the authority have, in a case not falling within proviso (*a*) to the preceding paragraph, omitted to procure a sample of milk from the seller or consignor in accordance with the foregoing provisions, no proceedings under this Act shall be taken against the purveyor in respect of the sample procured from him.

(4) Any sample so procured in the course of transit or delivery shall be submitted for analysis to the analyst to whom the sample procured from the purveyor is or was submitted.

(5) If proceedings are taken against the purveyor, a copy of the certificate of the result of the analysis of every sample so procured in the course of transit or delivery shall be furnished to him, and every such certificate or copy shall, subject to the provisions of Section 81 of this Act (Evidence of Certificates of Analysis and presumptions), be admissible as evidence on any question whether the milk sold to the purveyor was sold in the same state as it was when he purchased it.

(6) The authority by whose officer, or within whose area the first-mentioned sample was procured may, instead of, or in addition to, taking proceedings against the purveyor, take proceedings against the seller or consignor.

(7) If a sample of milk of cows in any dairy is procured in course of transit or delivery from that dairy the dairyman may, within sixty hours after the sample was procured, serve on the authority by whose officer the sample was procured a notice requesting them to take immediate steps to procure as soon as practicable

a sample of milk from a corresponding milking of the cows and, thereupon, paragraphs (2) to (5) of this Schedule shall, so far as applicable, apply with any necessary modifications.

Provided that the person procuring the sample shall be empowered to take any such steps at the dairy as may be necessary to satisfy him that the sample is a fair sample of the milk of the cows when properly and fully milked.

Specimen forms for use with this Act will be found in Appendix I, pages 461 to 466.

Tuberculosis Order, 1938

Definitions : " Milk " includes cream and separated or skimmed milk.
" Tuberculous emaciation " means emaciation due to tuberculosis.

This Order deals principally with removal of tuberculous animals from dairy herds, with consequent compensation to owner or owners of such animals. Conditions affecting animals which must be notified have already been detailed in Chapter III. As regards milk, the Order states :

(1) The milk from any animal affected with chronic disease of the udder or tubercular emaciation or is suffering from a chronic cough or shows definite clinical signs of tuberculosis shall not be mixed with other milk until the animal has been examined by a veterinary surgeon.

(2) The milk must not be mixed with other milk until after six weeks have expired to enable microscopical and biological tests to be carried out if these are considered necessary and until the owner has been notified that this is no longer necessary.

(3) All such milk must be effectively boiled or sterilised and all utensils which have come into contact with such milk shall be effectively sterilised either with steam or boiling water before any other milk is placed therein.

Notice is served on the owner, in the case of any suspected animal, for its isolation and prohibiting the mixing of milk. This Order has no preventive value and gives no guarantee that any particular milk supply is free from tubercle bacilli even after an affected animal has been eliminated.

Milk (Special Designations) Order, 1938

Amendments to the Order of 1936 have already been incorporated in that Order which is set out on pages 425 to 428.

Milk and Dairies (Amendment) Order, 1938

This Order repeals Articles 8, 9 and 10, dealing with veterinary inspection of milk-producing animals. Amendment was rendered necessary by the transfer of powers of veterinary inspection from local authorities to the Minister of Agriculture and Fisheries.

Sale of Milk Regulations, 1939

These Regulations were made by the Minister of Agriculture and Fisheries under Section 23 of the Food and Drugs Act, 1938.

Article 1. Milk not sold as separated or condensed milk which contains less than 3 per cent. milk fat shall be presumed, until the contrary is proved, to be not genuine by reason of the abstraction therefrom of milk fat or the addition thereto of water.

Article 2. Milk not sold as separated or condensed milk which contains less than 8·5 per cent. of milk solids other than fat shall be presumed to be not genuine by reason of the abstraction of milk solids other than fat and the addition thereto of water.

Article 3. Separated milk, not being condensed milk, containing less than 8·7 per cent. of solids other than fat shall be presumed to be not genuine until the contrary is proved.

Defence (General) Regulations, 1939

Regulation 54B. This Regulation gives Local Authorities power to install and operate pasteurising plant. Such authorities are to be treated as wholesalers for this purpose and are to be entitled to the margins allowed for acting as wholesalers and for heat-treating milk.

Regulation 55G. This important Regulation implements the policy of the Government already outlined in the White Paper, " Measures to Improve the Quality of the Nation's Milk Supply " (Cmd. 6454) which is further considered in Chapter XII.

The Scheme will be applied to urban areas in which retail deliveries of milk have been rationalised. No area will, however, be specified until the Minister of Food is satisfied that facilities exist for the supply of adequate quantities of the permitted classes of milk to meet requirements of the specified district. In such areas, the provision of sufficient plant will be a deciding factor but meanwhile, Dairymen's Wartime Associations have been asked to prepare schemes for supplying permitted classes of milk to customers in their separate areas.

The Regulation states that milk may not be sold by retail or supplied free of cost in any specified area unless it is :

(1) Tuberculin tested milk sold as such ; or

(2) Accredited milk sold as such and provided that such milk is the product of one herd ; or,

(3) Heat-treated milk, pasteurised milk or sterilised milk.

This restriction does not apply to :

(*a*) Milk sold to a dairyman for re-sale but milk sold by the purchasing dairyman must comply with the requirements of the Regulation.

(*b*) Milk sold for use in the manufacture of any other product.

(*c*) Milk sold for live-stock feeding.

While milk sold to cafés and restaurants must comply with Regulation, such article when sold for refreshment or as a part of a meal, is exempt from the foregoing conditions.

Heat-treated, pasteurised and sterilised milks are required to satisfy certain laboratory tests which have been prescribed by the Minister of Health in the Heat-treated Milk (Prescribed Tests) Order, 1944,(see pages 438 and 439). Food and Drugs officers are requested to notify Area Milk Officers of the Ministry of Food in all cases where milk fails to satisfy prescribed tests while a monthly return is to be submitted to the Ministry of Food of the number of samples taken together with details of those which have proved to be unsatisfactory. When such milk is sold in any of the specified areas in closed containers, such containers must bear the words, " Heat-treated," " Pasteurised " or " Sterilised " as case may require. Foregoing descriptions may not be applied to milk sold by any distributor unless it complies with requirements of the Regulation. Milk sold as " Pasteurised " must comply with conditions laid down in the Milk (Special Designations) Orders, 1936 to 1946. In all cases where a dairyman retails milk both inside and outside a specified area from the same premises, all such milk sold by him must be of permitted classes and comply with requirements of the Regulation. Plant holders are to be licensed by Minister of Food but such plants as are at present licensed by local authorities under the Milk (Special Designations) Orders, 1936 to 1946 may continue as at present and are accepted as being satisfactory. Before any licence is issued, milk from all plants must be sampled and tested by prescribed tests.

This Regulation will be enforced by Food and Drugs authorities and sampling officers of these authorities are empowered to enter and inspect premises and utensils used for sale of milk by retail and to take samples of milk for examination and testing. In districts where local authority grants licences under the Milk (Special Designations) Orders for the production of pasteurised milk, and such local authority is not a Food and Drugs Authority, both authorities will be responsible for enforcement of the law relating to heat-treated milk. Such an arrangement is doubtless a wartime expedient and ultimately supervision of heat-treatment plants and of heat-treated milk will be placed in the hands of one authority. It should be pointed out that the majority of Food and Drugs Authorities, except in large cities, are County Councils who employ, as sampling officers, a variety of officials, many of whom do not even possess an elementary knowledge of methods of heat-treatment and employment of such officials in a supervisory capacity is to be deprecated. It should be emphasised, however, that the powers and duties of licensing authorities under Milk (Special Designations) Orders remain unaltered.

Frequent sampling of tuberculin-tested milks is to be undertaken, these being examined for presence or absence of tubercle bacilli. If Accredited milk from more than one herd is sold by any dairyman, each supply of milk is to be kept separate and clearly marked so that milk of each herd can readily be identified. Any accommodation milk obtained from other sources must not be sold as Accredited milk and, if not tuberculin tested, such milk must comply with provisions laid down for heat-treated milk.

No Orders specifying areas have yet been made but an early introduction of the Regulation in all urban areas is vital to the health of the community. It is to be regretted, however, that Accredited milk, an article which cannot under any circumstances be recognised as a *safe* milk, should have been included in the Regulations.

Regulation 62. This Regulation gives power to War Agricultural Executive Committees to serve direction upon the owner of a cowshed or dairy who has failed to comply with the requirements of the Local Authority as regards structural alterations under the Milk and Dairies Order, 1926, requiring him to carry out such work within a reasonable period of time. In default, the Committee can carry out the work and recover the cost. Failure to comply with the direction renders the owner liable to prosecution for an offence against the Defence Regulations.

It should be noted that Committee's powers in this direction extend only to such works of repair as may be considered *reasonable* having regard to general shortage of labour and materials at the present time. It must also be pointed out that reconstruction or repair of cowsheds will soon be dealt with by Ministry of Agriculture officials whose power to refuse registration, subject to appeal, is laid down in Food and Drugs (Milk and Dairies) Act, 1944. (See pages 439 to 441.)

Milk (Special Designations) Regulations, 1941

These Regulations modify Order of 1936 so far as pasteurisation of milk is concerned by permitting use of the High-Temperature, Short-Time method of pasteurisation. The conditions specified will be found detailed in Chapter IX, pages 315 to 324, while the modified form of licence is set out in Appendix I. Official sanction to the employment of this method of treatment has caused considerable controversy.

Milk (Use of Churns) Order, 1941

This Order states that it is an offence against the Defence (General) Regulations to :

(1) Use a churn belonging to another person for any purpose other than for milk collection or delivery.
(2) Use a churn (other than a hired churn) for milk collection or delivery without the consent of the owner.
(3) Keep a churn for an unreasonable period without consent of the owner.
(4) Wilfully damage a churn or obliterate the mark or name without consent.

Milk (Sales to Distributors) Order, 1942

This Order, amongst other matters dealing with terms under which the Minister of Food re-sells milk to distributors, makes it clear that, unless otherwise agreed, the buyer must supply clean churns to receive the milk. It emphasises also that this does not mean that the purchaser can agree with the producer to send back churns in a dirty condition or that in the event of the producer supplying churns, the distributor is under no obligation to cleanse them after receipt of milk.

Milk (Special Designations) Regulations, 1942

These Regulations modify Milk (Special Designations) Orders of 1936 and 1938 to permit animals in tuberculin-tested herds to be vaccinated with live abortus vaccines subject to approval of the Minister of Agriculture and Fisheries and with vaccines approved by him.

Milk (Use of Churns) Order, 1942

This Order makes it an offence to use any churn belonging to the Minister of Food and bearing certain marks without consent of the Minister or a a Regional Milk Supply Officer.

Milk and Dairies Regulations, 1943

Under these Regulations, Article 21 of the Milk and Dairies Order, 1926 is repealed and following article substituted :

Article 21. Every cowkeeper or dairyman shall cause all vessels (including the lids of such vessels) and appliances used or intended to be used by him for containing, measuring or stirring milk, or for any other purpose for which they may be brought into contact with milk, to be kept at all times in a state of thorough cleanliness.

For this purpose—

(i) every such vessel, lid and appliance (except a mechanical milker or similar appliance used in milking which is efficiently cleansed before it is brought into contact with milk) shall be thoroughly washed as soon as may be after use, and shall be cleansed and scalded with boiling water or steam before it is used again ;

(ii) no oxidising or preservative agent other than such solutions of sodium hypochlorite as may from time to time be approved by the Minister of Agriculture and Fisheries shall be used in the cleansing of any such vessel, lid or appliance and where such solutions so approved as aforesaid are used, all trace thereof shall be removed before such vessel, lid or appliance is brought into contact with milk ;

(iii) every such vessel, lid and appliance when not in use shall be stored in a clean place and shall be protected from dust and dirt ; and

(iv) no such vessel or appliance shall be used for containing, measuring or applying any process or treatment to any article other than milk or milk products.

This Article permits, as a war-time measure, the employment of sodium hypochlorite solutions specified by Minister of Agriculture and Fisheries in addition to normal methods of sterilisation used, but nowhere is it stated that utensils should be sterilised, a process of extreme importance in ensuring production and distribution of clean milk. Further, no control over utensils employed for heating water used for cleansing purposes is provided and there is nothing to prevent the domestic copper in which household linen has been boiled being used for this purpose. Subsection 3 of this Article states that utensils should be stored in a clean place but opinions as to what is a clean place are likely to differ considerably and a dairy or milkroom should certainly have been specified as the place of storage.

Defence (Sale of Food) Regulations, 1943

Article 3. Provides power to take samples of any rationed food *including milk* by a Sampling Officer within the meaning of the Food and Drugs Act, 1938, on production of some duly authenticated document showing his authority under that Act. The Sampling Officer must be empowered to take such samples by a warrant in writing issued by the Ministry of Food.

This warrant is usually issued by the Food Executive Officer for the district concerned.

Milk (Use of Bottles) Order, 1943

This Order makes it an offence to :

(1) Wilfully destroy any milk bottle.

(2) States that any person having in his custody a milk bottle delivered to him by his distributor shall :

- (*a*) Keep same in clean and sound condition.
- (*b*) Use same only for milk.
- (*c*) Shall not retain bottle for an unreasonable time.

(3) A dairyman shall not use bottles belonging to another dairyman.

(4) Persons supplying milk in bottles shall take steps to recover same within a reasonable time.

Milk (Special Designations) Order, 1943

This Order amends Paragraph 1 of Section A of Part 2 of the Third Schedule of the Milk (Special Designations) Order, 1936 and the amendment has already been included in the conditions specified in Chapter VIII, page 237. The circular accompanying the Order states that Accredited milk herds are affected and the Order, as altered, gives effect to proposals for *more satisfactory* arrangement of veterinary examinations set out in the Government White Paper on Milk Supply. The suggestion that veterinary inspections are to be more satisfactory will no doubt be received with reservation.

The Heat-Treated Milk (Prescribed Tests) Order, 1944

This Order prescribes laboratory methods to be employed in testing heat-treated milk, with which such milk must comply to satisfy the requirements of Defence Regulation 55G (see pages 435 to 436). Article 2 of the

Order states that the phosphatase and methylene-blue tests shall be employed and such tests must be carried out in a manner prescribed in parts 1 and 2 of the Schedule to the Order. The methods to be used in making such tests have already been set out in Chapter X, pages 382 and 408. It is further stated that :

(1) The phosphatase test shall be deemed to be satisfied by milk giving a reading of 2·3 *Lovibond blue units or less*.

(2) The methylene-blue test shall be satisfied if the milk fails to decolorise methylene blue in *thirty minutes*.

In connection with latter test, it is further emphasised that milk to be tested must be kept at atmospheric shade temperature not exceeding 65° F. until test is commenced and such test shall be begun not earlier than 9 a.m. and not later than 10 a.m. on day *after* the sample has been taken.

Food and Drugs (Milk and Dairies) Act, 1944

This important Act makes the following drastic changes in existing law relating to milk production :

(1) Registration of dairy farmers producing milk for the liquid market is to be carried out by Minister of Agriculture and Fisheries.

(2) Enforcement of all provisions set out in Milk and Dairies Regulations relating to premises of dairy farmers will be carried out by Minister of Agriculture and Fisheries.

(3) Licences for production of designated milks will be issued by Minister of Agriculture and Fisheries.

(4) Registration of dairy farms can be refused or cancelled by Minister of Agriculture and Fisheries. Person affected has right of appeal to Minister within twenty-one days.

(5) Local authorities are given power to refuse or cancel registrations of dairies and dairymen, Section 22 of the Food and Drugs Act, 1938 being amended accordingly.

(6) Any Regulations dealing with Milk and Dairies and Special Designations of *raw* milk will be made jointly by Ministers of Health and Agriculture and Fisheries.

Definitions. These are to be found in Section 8.

" Dairy farm " means any farm cowshed or other premises being a dairy within the meaning of the principal Act on which milk is produced from cows, but does not include any part of any such farm or premises on which milk is manufactured into other products unless the milk produced on the farm or premises forms a substantial part of the milk so manufactured.

If any question arises whether milk produced on a farm or other premises forms a substantial part of milk that is to be manufactured into other products at such premises, that question shall be determined by Minister of Agriculture and Fisheries.

" Dairy farmer " means a dairyman within the meaning of the principal Act who produces milk from cows.

" Principal Act " means the Food and Drugs Act, 1938.

" Raw milk " means milk which has not been treated by heat.

Section 1. This Section amends Section 20, sub-section 1, paragraph (*a*) of the Food and Drugs Act, 1938 (page 429), to provide for :

(i) Registration of all dairy farms and persons carrying on or proposing to carry on the trade of dairy farmer by Minister of Agriculture and Fisheries.

(ii) Refusal of such registration if Minister is of the opinion, having regard to conditions existing at the premises to be registered, that regulations cannot be complied with when the registration should be refused, and for cancellation of any such registration by Minister if regulations are not being complied with and such registration should be cancelled.

In order to prevent the arbitrary use of powers set out in (ii) above, the regulations when issued shall :

(*a*) Require notice to be given to person affected of any intention to refuse or cancel registration, setting out the grounds on which it is alleged that regulations cannot be or are not being complied with, as case may be and stating that person's rights to make objections and representations in accordance with regulations.

(*b*) Enable the said person within not less than 28 days, in case of refusal, and 21 days, in case of cancellation from date of the service of such notice, to object in respect of all or any of the grounds stated in said notice, that regulations are or can be complied with.

(*c*) Provide for such objection to be referred to a tribunal constituted in accordance with the regulations.

(*d*) Provide for procedure of the tribunal and for person objecting to appear before tribunal, call witnesses and have premises inspected.

(*e*) Require tribunal to determine if objections can be upheld or, if not, on which of the grounds in respect of which they are made they are not made out. Majority vote of tribunal to decide.

(*f*) Determination of tribunal to be reported to Minister of Agriculture and Fisheries and to be communicated by him to person objecting. Determination of tribunal as stated in report to be conclusive evidence of facts found thereby.

(*g*) Enable said person, within the prescribed time to make representations to Minister of Agriculture and Fisheries that registration should not be refused or cancelled on grounds stated in notice mentioned in paragraph (*a*) above.

(*h*) Provides that no registration shall be cancelled :

- (i) Until prescribed time for making objection or representation under regulations has expired.
- (ii) In case of an objection being entered within specified time, until report of the tribunal has been received and considered by Minister.
- (iii) In a case where a representation is made to Minister within that time until representation has been considered by him.

Any premises immediately before the appointed day for the Act to come into operation and any person then carrying on trade of dairy farmer shall be deemed to have been registered in accordance with the Milk and Dairies Regulations by Minister of Agriculutre and Fisheries at the commencement of Act. Such Regulations shall include a provision for ascertaining premises and persons deemed to have been registered as aforesaid and for making consequential adjustments of register kept by any authority under the said Regulations immediately prior to commencement of this Act.

Power is also given to include in any Regulations made which deal with inspection of dairies and persons in and about dairies (paragraph (*b*), sub-section (1), Section 20, Food and Drugs Act, 1938) to provide for issue of Regulations dealing with inspection of cattle on dairy farms.

In addition, paragraph (*h*) of same sub-section and Section is amended to include power to make Regulations governing storage of milk.

Section 2. Amends Section 21 of the Food and Drugs Act, 1938 as follows :

(1) Regulations dealing with special designations in connection with milk shall cease to be contained in Milk and Dairies Regulations and shall be separate regulations to be entitled Milk (Special Designation) Regulations.

(2) As regards raw milk, power of making such Regulations is to be exercised jointly by Minister of Health and Minister of Agriculture and Fisheries and designations of raw milks shall be such as the Ministers consider appropriate.

(3) Regulations regarding any special designation of raw milk shall provide for granting by Minister of Agriculture and Fisheries, instead of by Minister of Health or County Councils or local authorities of licences to producers of raw milk authorising use of that special designation.

Section 3. Amends Section 22 of the Food and Drugs Act, 1938.

The amended section of this Act will be found set on page 430 of this chapter.

Section 4. Contains supplementary amendments of the Food and Drugs Act, 1938.

By this Section, Section 92 of the Food and Drugs Act, 1938, which contains supplementary provisions as to Milk and Dairies Regulations, is made applicable to Milk (Special Designations) Regulations and any reference to Minister is to be construed as references to the Minister of Health and the Minister of Agriculture and Fisheries. It also provides a saving clause as to authorities who shall enforce or execute any Regulations. A further provision is that Milk and Dairies Regulations shall provide for constitution of a *Central Committee* and of *County Committees* for each administrative county who shall keep under review the operation of any Milk Regulations County Committees will forward their suggestions to the Central Committee who, in turn, will make its recommendations direct to the Minister of Agriculture and Fisheries.

Section 5. Provides for compensation to displaced officers to be paid *by the local authority who employs such officer.*

Section 6. Provides for continuance of superannuation rights of officers transferred to the Ministry of Agriculture from local authorities.

Section 7. Deals with expenses incurred under the Act.

Section 8. Sets out definitions already dealt with on page 439.

Section 9. States that Act shall come into operation on a day to be appointed by Minister of Health.

No date has yet been fixed for commencement of the Act.

In practice, once the appointed day arrives the alterations affecting local authorities and their officers will be as follows :

(1) Local authorities cease to be responsible for registration of milk producers and supervision of milk production at farms.

(2) County Councils and local authorities cease to be responsible for issue of licences to designated raw milk producers.

(3) Local authorities continue to be responsible for :
  (*a*) Supervision of premises of producer-retailers so far as retail portion of the business is concerned.
  (*b*) Compliance with all Acts, Orders or Regulations relating to erection or adaptation of buildings.
  (*c*) Drainage, sanitation, sewage disposal and mains water supplies.
  (*d*) Abatement of nuisances.
  (*e*) Procuring " appeal to the cow " samples at point of production.

(4) Local authorities continue to be responsible for enforcing all provisions of any Regulations dealing with sale of designated milk, including producer-retailer's premises but are not authorised to carry out investigations at point of production even though such farms are in their own areas.

(5) Local authorities have power to refuse or cancel registration of both wholesale *and* retail dairymen *if the public health is or is likely to be endangered.*

Milk (Special Designations) Regulations, 1946

These Regulations amend the prescribed standards for pasteurised milk laid down in the Third Schedule of the Order of 1936. The prescribed tests for all pasteurised milks are similar to those set out in the Heat-Treated Milk (Prescribed Tests) Order, 1944, on page 439. A Schedule to the Regulations sets out the methods of heating which are discussed in Chapter X, pages 382 and 408.

CHAPTER XII

THE FUTURE OF THE MILK INDUSTRY

THROUGHOUT the preceding chapters an attempt has been made to elaborate the measures necessary to secure stringent control of all milk supplies so that this foodstuff may be produced, delivered and consumed in a clean and safe condition. Conversely, the multitude of ways in which milk may be rendered unfit for human consumption have been illustrated. The present position cannot be said to be entirely satisfactory and it is necessary now to briefly survey schemes which have been devised or which are at present in existence whose aims have been improvement of the milk supply. The schemes which have been introduced with such an end in view are :

(1) The Accredited Milk Scheme.
(2) The Attested Herds Scheme.
(3) The National Milk Testing Scheme.

(1) The Accredited Milk Scheme

This scheme was sponsored by the Milk Marketing Board and was designed to improve the hygienic quality of the country's milk supplies. It must be emphasised that from its inception this proposal could only be considered as a preliminary step to further improvements.

Briefly, the scheme provided that, after May 1st, 1935, all registered producers presenting to the Board the Grade A certificates then in force, would be placed upon the Accredited Roll and would receive one penny per gallon premium for their milk irrespective of the use to which it was to be put by the purchaser. These premiums were to be paid from a central fund created by the Board by means of a levy one-sixteenth of a penny per gallon from all registered producers. Wholesale producers and producer-retailers were entitled to the premiums, while holders of Grade A licences automatically qualified. Producers who enrolled were known as " Accredited Producers."

When the Milk (Special Designations) Order, 1936, became law, milk produced by enrolled " Accredited Producers " became officially recognised as Accredited milk, and is so recognised at the present time, the premium now paid amounting to 1¼*d.* per gallon over and above the normal pool price. To obtain an Accredited licence, which is essential before the designation " Accredited " can be used, a producer must apply to the licensing authority requesting that his herd be clinically examined and his milk sampled. This veterinary examination and initial sampling must take place at least one month prior to a licence being granted. A producer may be called upon to pay the maximum annual licence fee set out in the Order and in districts where it is customary for the local authority to make a charge, the cost of initial inspection and sampling must also be borne by him. The examination which puts the onus of maintaining the standard of milk on the producer is made only while the milk is nominally in his possession, the wholesale producer's responsibility ending when such milk has been delivered in sealed containers to the depôt of the distributor.

The Accredited Milk Scheme and the production of Accredited milk under the Order of 1936 has resulted in a general improvement in the cleanliness of milk supplies while the educational value of the work has been of considerable value. Although these advantages have been derived and the Scheme has proved its usefulness, there have been grounds for serious criticism. In the first place, a farmer is required to pay a licence fee for producing such milk while in some counties he has also had to pay for veterinary inspections and even for the laboratory examination of samples. It must be emphasised once again that all such examinations should be carried out free of all cost to the producer. Two other disadvantages also exist. One is that the Scheme is concerned chiefly with the production of milk and not with its distribution so that there is nothing to prevent mixing of clean milk with a dirty product before it reaches the consumer. Indeed, at many collecting stations, this has always been, and still is, a universal practice. A further drawback is that the scheme does little to eliminate bovine tuberculosis or other diseases from the milk supply.

It is also to be doubted whether the hygienic quality of milk has been materially improved by the offer of monetary inducement to producers. By far the greater number have not attempted to obtain licences to produce Accredited milk, probably because of the extra effort and care involved or because they do not realise the advantages to be derived from participating in the Scheme. Again, many producers still consider the premium offered is insufficient, in spite of a 25 per cent. increase since the commencement of the present war. Those who have commenced to produce such milk, and many thousands are now doing so, have only to attain a standard well within reach of all producers, a standard which should be compulsory rather than optional, and which should carry no extra bonus. Further, as already mentioned, such milk, bearing as it does the label " Accredited," may be bought by many people as a guaranteed milk. This fact takes on an increasing importance when it is remembered that no guarantee of safety is given if the milk is to be sold in its raw state, the liquid not being obtained from tuberculin-tested cows but from animals which merely undergo a clinical examination at intervals. Savage has stated that evidence in his possession shows that Accredited milk is infected with tubercle bacilli to a higher degree than ordinary raw milk. Unfortunately, it is all too common for a producer of tuberculin tested milk to maintain an Accredited herd into which he moves any reactors which may be discovered. In short, it may be stated that the Accredited Milk Scheme and the resultant Accredited milk has caused an increased production of " clean " milk, but its value as regards production of a " safe " milk still remains doubtful.

(2) The Attested Herds Scheme

This scheme, which was sponsored by the Ministry of Agriculture and Fisheries, came into operation on February 1st, 1935, and was primarily designed to operate for four years. Its object was to establish a reservoir of cattle which could be guaranteed free from tuberculosis. Although attainment of this aim was obviously to be achieved slowly, the Ministry regarded the scheme as a prelude to a more strenuous, and expensive, long term policy which the present war has, without any doubt, delayed.

At its inception, the scheme provided that any owner of cattle who had taken steps to eradicate tuberculosis from his herd and who was a " Registered producer " under the Milk Marketing Scheme, was entitled to apply to the Ministry of Agriculture for an official test of his herd. If the owner of such herd satisfied the Ministry :

(1) That the management of the herd and the conditions under which it was kept were suitable :

(2) That no reactors had been found in the herd on the occasion of the last two tuberculin tests made on the owner's behalf (provided that these tests had been carried out at an interval of not less than six and not more than twelve months between the tests) and that the latter of the two tests had been carried out not more than twelve months before the date of the application ; and

(3) If the producer gave a written undertaking to observe the rules applicable to attested herds ;

an official tuberculin test of the animals in the herd was made free of charge by the Ministry. If no reactors were found by such official test, the Ministry issued a Certificate of Attestation in respect of the herd which was then added to the Register of Attested Herds kept and published by the Ministry.

The Certificate of Attestation was valid for one year and was then renewable at the end of that period but this period was later extended. At the end of such period, a further tuberculin test was made of the animals. If any reactor was found, the Certificate was suspended until the following conditions were complied with :

(1) Any reactors had to be immediately isolated from the herd and disposed of as quickly as possible and the premises disinfected. During the period of suspension, non-reactors in the herd were not permitted unrestricted entry into another Attested Herd.

(2) Non-reactors had to be submitted to a further official test not earlier than sixty days from the date of completion of the disinfection of the premises.

(3) If no reactor was revealed as a result of re-test, the Certificate was renewed for a further six months. If any reactor was found following a re-test, it had to be removed from the herd and the premises again disinfected. A second official re-test was carried out at the expiration of a further sixty days from date of completion of the last disinfection of the premises.

(4) If any additional reactor was found as a result of a second re-test, it was assumed that the disease had a firm hold on herd and the Certificate was cancelled.

(5) To regain the Certificate, a producer had to follow the same procedure as when he first applied.

All animals introduced into the herd were required to come from an approved source and were tested, on entry, free of charge by the Ministry. Animals added to a herd had to be certified by a veterinary surgeon as having passed the tuberculin test within fourteen days prior to their movement. All new animals had to be isolated from the remainder of the Attested Herd for a period of sixty days and at the end of this period, had to pass a further tuberculin test before being introduced into the main herd. If an animal reacted, it had to be removed and the premises disinfected. The movements of attested animals were strictly controlled by the Ministry. Swine kept on the same premises as attested cattle might have their movements limited and the owner might be required to have them tested at his own expense. Milk used for feeding purposes had to be pasteurised or sterilised when obtained direct from a non-attested herd. Fences had to be maintained to prevent infection from an adjoining herd or herds. The Ministry attached great importance to disinfection of premises and vehicles and supplied instructions regarding methods to be employed.

In June, 1939, the Scheme was revised, the Ministry of Agriculture deciding to offer an increased financial inducement to farmers to eradicate tuberculosis from their herds. This payment was additional to a bonus already given for milk produced from such herds and was no doubt rendered necessary on account of the somewhat meagre response to the original scheme.

This new proposal was briefly as follows: Where an owner could produce a veterinary certificate stating that he had reduced the number of reactors to the tuberculin test in his herd to not more than 10 per cent., the Ministry of Agriculture would favourably consider applications for further tests, up to a maximum of four. The contribution payable in respect of each of these "assisted" herd tests was fixed at a maximum rate of 2*s*. 6*d*. per head of cattle tested in excess of five and not exceeding forty-five and 2*s*. in respect of each animal tested in excess of forty-five, plus a sum of £1 1*s*. per herd. It was also stipulated that this contribution could in no case exceed the charges made by the veterinary inspector who carried out the tests. It was usual for these "assisted" tests to be carried out by a veterinary surgeon employed by the owner of a herd. It has been estimated that, in the case of a herd of twenty cows, the contribution towards the cost of testing would be in the region of £38, and for replacement of reactors, £32. The Certificate of Attestation was not issued for a limited period or subject to periodical renewal but remained in force until surrendered by the owner or cancelled or revoked by the Minister.

A further amendment to regulations governing the original Scheme provides that in any case where a herd failed to pass an official test before a Certificate of Attestation was granted, the owner, instead of having his application rejected as was formerly the case, could apply for further official tests at the expense of the Ministry up to a maximum of three complete herd tests, making four in all. When the whole herd passed one of these tests, a Certificate of Attestation was issued. Once a herd had been accepted for an "assisted" test or for the official additional tests mentioned above, it was termed a "supervised" herd and the owner was required to carry out certain regulations, dispose of reactors and disinfect premises.

Satisfactory as the Scheme may eventually turn out to be, it is far from perfect at the present time. Comparatively few milk producers in this country are likely to comply at present with the necessarily stringent conditions which, at the farm, are more rigid than those required from producers of Tuberculin Tested milk. Those persons who have usually qualified are:

(1) Producers of Tuberculin Tested milk.

(2) Producers who have, for their own satisfaction, subjected their herds to tuberculin tests but who have not limited themselves to the terms of the Milk (Special Designations) Orders.

(3) Producers who, by reason of breeding their own cattle, have been maintaining their herds as self-contained units.

At the commencement of the present war, entries to the Scheme were confined to tuberculin-tested herds, but in 1944 it was announced that the Scheme would be reopened from July 1st of that year on a revised basis. The conditions now applicable are briefly as follows:

(*a*) No financial assistance is given towards cost of qualifying tests and no bonus payments are made to new herds entering the Scheme.

(*b*) Herds already registered are not to be affected by these conditions.

(*c*) The Minister must be satisfied that the management of the herd and the condition under which it is kept are suitable.

(*d*) Certificates of two consecutive tuberculin tests, carried out at an interval of not less than sixty days and not more than twelve months between the tests and at which no reactor has been found, must be produced.

(*e*) In the case of a new herd being constituted with animals transferred from other Attested Herds, the Minister is prepared to consider the issue of a Certificate of Attestation at once without further test.

One serious omission from the conditions laid down is that no mention is made regarding the slaughter of reactors which may be freely sold for subsequent inclusion in non-attested herds. It has been stated that the slaughter of such animals is impossible by virtue of the high percentage likely to be discovered. This, however, appears to be fallacious. Owing to the small proportion of the cow population of this country which is likely to come within the purview of the Scheme, slaughter of reactors from attested herds would not be likely to cause a serious decrease in the number of animals available for milk production and this procedure would certainly prevent spread of infection. This method of disposal should have formed an integral part of the Scheme.

The Scheme also suffers from the following disadvantages :

(1) Conditions are so rigorous that only owners of herds which are free or practically free from tuberculosis can ever hope to profit until several years have elapsed.

(2) Guaranteed premiums paid for milk obtained from such herds are insufficient to induce the majority of owners of herds with an incidence of this disease as low as 10 per cent., to make the initial effort and incur the necessary expense.

As an inducement to participate in the Scheme, the owner of an Attested herd receives a bonus for his milk over and above the normal market price. It should, however, be remembered that attested cattle sell at an enhanced value and that an attested herd will, by this increase in value, be a greater asset to its owner. Furthermore, the presence of tuberculosis in a herd means reduced milk yield, shorter milking life and an increased susceptibility to other diseases.

(3) The National Milk Testing Scheme

Following the Government's Memorandum on Milk Policy (Cmd. 6362) which was issued early in June, 1942, the Ministry of Agriculture published its provisional scheme for a National Milk Testing and Advisory Service for milk producers and distributors. There can be no doubt that on account of the serious loss of milk through souring during the summer of the previous year and by the shortage of supplies of the commodity owing to war conditions some such scheme was essential. During that period, the Ministry of Food is said to have suffered a loss of £1,000,000, due to the premature souring of 10,000,000 gallons of milk. An Advisory Committee was constituted to supervise the Scheme, drawn from representatives of the various Government Departments concerned, and the dairy industry.

This Advisory Committee appointed a Technical Sub-Committee to consider and advise on the technical aspects of the Scheme, and much progress has been made in this aspect of the work. One of the results of the Sub-Committee's deliberations was to obtain the approval of the Ministry to a Platform Rejection Test (the 10-minute Resazurin test) which may be applied daily to milk suspected of possessing poor keeping quality and a standard test for routine examination of farm supplies to be applied at frequent intervals (usually fortnightly) to all supplies at the place of first delivery in order to assess their keeping quality and to provide a basis for advisory work. There has been a spate of memoranda regarding prescribed tests, technique of hand or machine cleansing of churns and tankers, while copies of laboratory reports have been issued.

Generally, the Scheme seeks to bring about an all-round improvement in all farm milk supplies while its immediate objective is prevention of loss through souring during the summer months, particularly of bulked milk sent to creameries, collecting stations and milk processing depôts. War-time difficulties have interfered with the full development of the Scheme which aims at classifying the milk into three grades, viz. :

(1) Market milk—for general sale as liquid milk.
(2) Salvage milk—suitable for manufacturing purposes.
(3) Reject milk—to be returned to the producer as unfit for use.

Owing to the prevalent shortage of supplies generally, only a small proportion of the total amount of milk received has been returned to the producer nor is it likely to be, until more favourable conditions allow such a procedure to be generally employed although the buyer is still free to reject milk if he considers same is unsuitable for the liquid milk market. Difficulties arising in the operation of the Scheme have made it impossible to introduce a national system of price differentiation according to quality which is the real object in view, but provision for rejection of milk has been included in the form of contract. In spite of this lack of favourable circumstances, the Scheme is exerting a beneficial influence on the standard of milk supplies passing through the larger creameries and depôts. At the end of 1944, approximately 92·2 per cent. of producers' samples and 37 per cent. of samples from producer-retailers were being examined once a fortnight under the Scheme.

Provincial Dairy Bacteriologists were delegated with the responsibility of assuring necessary sampling and testing facilities at the larger depôts and creameries and, although in many instances such facilities were available, a considerable extension of laboratory accommodation has had to be made. From the commencement of operations, it was primarily agreed to deal with milk from wholesale producers, the product of producer-retailer's herds being left for later consideration. All large creameries, milk processing depôts and collecting stations receiving milk from a number of producers have had to provide laboratory facilities and staff necessary for operating the Scheme. The standard laid down for such premises was that these facilities were necessary for all units receiving milk from more than 100 producers or whose average daily intake was more than 2,000 gallons of milk. Smaller units were asked to co-operate with the Provincial Dairy Bacteriologists in the provision of such facilities in certain cases. Priority was given for the supply of laboratory equipment and in the reservation of laboratory staffs from military service.

Arrangements have also been made for training the necessary personnel to carry out the routine tests and the trade have been asked to supply suitable personnel for training. A standard platform rejection test (the 10-minute Resazurin test) and a longer, more exacting standard test of the same nature (see pages 383 to 389) have been adopted. Arrangements are also being made for the institution of Area Laboratories to test milk from the small distributing units and from producer-retailers, while Provincial Dairy Bacteriologists have been asked to examine and report upon the condition of milk churns and investigate failures in transport arrangements which may affect producers' milk supplies. They are also delegated with the duty of advising creameries and dairies generally as to improvements that are desirable and any cases of gross inefficiency or unwillingness to co-operate are reported to the Advisory Committee. Unsatisfactory tests result in advisory visits by officials of County Councils and of War Agricultural Executive Committees who have increased their staffs to deal with the increase in routine work which has been involved. The advice given to those producers whose milk when tested shows them to be in need of such assistance will be supplemented eventually by the provision of suitable literature, milk production demonstrations and training facilities for milkers. Producers will also be encouraged to take full advantage of various government schemes for improving the general management of dairy herds and provision of adequate equipment and facilities.

At the outset, the Scheme operated for a trial period of three months in the counties of Berkshire, Carmarthen, Cornwall and Shropshire but it has now been gradually introduced throughout the country, generally in the larger collecting depôts and processing dairies. In the four counties mentioned, approximately 5,000 samples were obtained during this trial period. Of the unsatisfactory samples discovered, approximately 91 per cent. failed to comply with the test on account of faulty technique in production, 82 per cent. on account of bad cooling arrangements, 62 per cent. were due to faulty sterilisation, 48 per cent. due to dirty utensils, 28 per cent. due to bad buildings and 15 per cent. to poor water supplies. It is obvious from the results of the experimental scheme that methods employed at the point of production are of the highest importance in obtaining clean milk of good keeping quality and this fact has already received considerable emphasis earlier in this volume.

It must be stressed that the Scheme is essentially an extension of commercial relations between buyer and seller and any requirements of the Food and Drugs Act, 1938 or of any Orders or Regulations relating to milk are in no way altered or over-ridden. Responsibility for administration of the Scheme rests with the Minister of Agriculture and Fisheries and the necessary arrangements are being brought into operation as quickly as possible. While its aims are commercial in application, there is no doubt that the Scheme will result, when fully operating, in attaining cleaner milk, particularly when price differentiation on a quality basis operates with the rejection of unsuitable milk supplies. The success of the proposals depends upon the fullest co-operation between Provincial Dairy Bacteriologists, who represent the Ministry of Agriculture and Fisheries, Medical Officers of Health and Sanitary Inspectors representing local authorities and Advisory Staffs of the County Councils and War Agricultural Executive Committees. Sub-Committees of the latter bodies in various counties have been formed to handle problems which must obviously arise out of the application of the Scheme, and on the majority of these the three interested parties mentioned above have representation, to the mutual advantages of all concerned. Indeed, the Minister of Health and the Minister of Agriculture and Fisheries recommend that public health officials should be co-opted to serve on such sub-committees in every county.

An interchange of views and assistance is generally necessary and none of those interested in the work can operate in a satisfactory manner without the other. Advisory work may be useless in dealing with some producers, in which case the statutory powers possessed by local authorities and those given in Defence Regulation 62 may have to be employed. Primarily, the

Scheme envisages a considerable amount of advisory work in which public health officers can be of assistance but which will chiefly be the duty of County Advisory Staffs. While it is essential in the interests of all concerned and of the consuming public to secure as much clean milk as possible, production and distribution have not been simplified by shortage of labour or materials, and war-time difficulties of replacement and repair. The fact that many producers have, since the commencement of the war, entered the liquid milk market for the first time, requires the greatest concentration upon methods and cleanliness.

The Minister of Health has asked for the co-operation of local authorities in working the Scheme and particularly in collection of samples from producer-retailers, as and when required, once the plans outlined are fully developed. It has been repeatedly emphasised, however, that none of the statutory powers of local authorities as regards handling, processing or conveyance of milk are abrogated by the proposals set out above. Further, as Provincial Dairy Bacteriologists are required to give special attention to those aspects of depot management such as churn washing and other processes which are likely to affect the keeping quality of milk, it is suggested that local authorities faced with any problems of a similar nature should consult the appropriate Provincial Dairy Bacteriologist. A list of such officials will be found on page 190.

While there can be no doubt that its advent is timely, the Scheme must be looked upon as an admission of the failure of existing legislation to produce a clean milk supply, and it is to be regretted that it needed the present war to bring about any improvement. Given proper co-operation between various interested parties, the Scheme will be of considerable use in improving the country's milk supplies and will no doubt eventually result in a higher standard of cleanliness amongst producers. Indeed, in several instances producers have had their milk contracts terminated on account of the unsatisfactory keeping quality of their milk and general conditions of production on their farms. On one point only can public health officials disagree with the Scheme as it stands. No provision is made for improving the *safety* of milk supplies generally, a point almost invariably overlooked by our legislators, although the proposals set out in the Government White Paper may, if they become law in their entirety, assist considerably in this direction.

Measures to Improve the Quality of the Nation's Milk Supply

The Government White Paper (Cmd. 6454) under the above title, was submitted to Parliament in July, 1943 and suggests striking innovations not only in production and distribution of milk but also in methods of supervision and administration, and it is these latter proposals which have caused considerable discussion and protests from many interested parties. The chief proposals are outlined briefly below with such comments as the authors think are necessary while general comments on the Scheme as outlined will be found on the pages which follow.

Briefly, the proposals are as follows :

(1) Improvement to be brought about in the health of cattle which comprise the milk-producing herds of this country including rearing and use of better bulls, culling of unthrifty or diseased cows and development of a more enlightened breeding policy.

Little fault can be found with this suggestion as it is an improvement long overdue and must obviously be the starting point for any improvement in the quality of milk supplies.

(2) Every herd of milk-producing animals throughout the country is to be inspected by veterinary inspectors at least once annually. Tuberculin-tested herds will be tested bi-annually as at present. Alterations are suggested in respect of Accredited herds which will be inspected once annually if milk from such cattle is to be heat-treated or every three months, as at present, if such milk is to be sold in its raw state. If, however, an Accredited herd is also attested, it will be inspected every six months. All other herds are to be inspected annually if milk is to be heat-treated, but if milk from such herds is not to be treated in this manner they will be inspected twice a year *within the limits of the staff available*. Additional inspections will be made if any herd has exhibited a bad disease history.

The words in italics above illustrate the main difficulty in implementing this Utopian proposal. There is, without any doubt, a shortage of veterinary officers at the present time and the suggestions made for herd inspections must, of necessity, await the training of additional members for the profession. Further, those veterinarians who are carrying out the work, do so at high pressure and it is difficult to visualise how increased inspection can be carried out for some considerable time to come. Even if staffs are increased, additional veterinary inspection can never hope to guarantee a *safe* milk supply continuously without the employment of laboratory tests. It should be noted that, under the Milk (Special Designations) Order, 1943, a retrograde step has been taken in that the proposals as to the inspection of Accredited herds have now become operative.

(5) It is proposed to centralise control of milk production under the direction of the Minister of Agriculture and Fisheries whose veterinary inspectors will be visiting farms in connection with herd inspection, and they will be required to supervise methods of production and the repair, alteration and maintenance of premises. The supervision of distribution will remain in the hands of Local Authorities as at present.

Local Authorities have carried out their obligations set out in various Acts and Orders, as well as existing legislation, often drafted in vague terms, has allowed and generally under great difficulties. In no case, however, have inspections been limited to one visit per annum as may be the case now the new proposals have become law. This suggestion has resulted in vigorous protests from various Associations of Local Authorities and other interested bodies without result and the transfer has now been made. It should be pointed out that the veterinary profession is now over-worked and likely to be more so, if animal health is to be properly supervised while they will be dealing with matters outside their usual ambit. Animal health is definitely a veterinary matter but it is difficult to agree to their suitability as advisers on methods of clean milk production, repair and reconstruction of cowsheds and dairies, provision of water supplies and investigations of cases of infectious diseases due to milk. For this reason the transfer of local authorities' inspectors is visualised in the Act.

(4) It is proposed by means of financial inducement to the producer to increase production of Tuberculin Tested milk and, by a reduction in its retail price, encourage an increasing sale to the consuming public.

Both suggestions deserve the highest commendation. In the past, the difficulty has been to dispose of such Tuberculin Tested milk as was produced on account of the high retail price and much of this valuable liquid has been mixed with ordinary supplies at collecting depots with consequent discouragement to the producer while depriving the consumer of a high-grade article. This proposal has already been made operative.

> (5) The Minister of Food will be empowered by Regulation to make it an offence to sell milk by retail in any area which may be scheduled unless such milk is either heat-treated, or is produced from Tuberculin Tested, or single Accredited herds.

Such a proposal as this would have been entirely satisfactory if Accredited milk had not been included. Once again it must be emphasised that such milk is not *safe* milk and the safety of the consuming public must be paramount if the milk supply of the nation is to be satisfactory. This proposal has now been legalised under Defence Regulation 55G but no Orders specifying areas have yet been issued. (See pages 435 to 436.)

> (6) Efforts are to be made to ensure that all milk supplies in schools under the Milk-in-Schools Scheme, shall be either heat-treated or the product of tuberculin-tested herds.

Any effort in this direction is sure to meet with universal approbation.

Generally it is doubtful if the correct conclusions have been reached and it is suggested that the proposals outlined and presumably to be ultimately legalised in their entirety by the Government, are more commercial in desire and intention than framed to improve the quality of milk for the benefit of the consuming public. From production to consumption, there is extremely poor co-ordination throughout and any public health gain may be incidental rather than intentional, a tendency which has become more noticeable since the commencement of the present war, while commercial expediency may over-ride public interest. During the past few years, many schemes of an advisory and educative character have raised great expectations. These have usually been based on grants of a monetary character given to encourage production of higher grade milk and while they have been largely accepted by the better type of producer, they have been ignored or greatly abused by others.

Once milk has been produced, the bulk of it is controlled, if not actually owned, by the Minister of Food and the Milk Marketing Board. The White Paper definitely envisages the concern of the Minister as to the protection of milk sold in certain areas but makes no mention of delays in transportation which have occurred, due to a policy of over-centralisation devised by the same Minister and Board and which is, without any doubt, a primary cause of sour milk. Indeed, the National Milk Testing and Advisory Scheme will be practically valueless unless the innumerable complaints of producers regarding unreasonable delays in collecting milk are properly met.

It must be recognised, however, that the present state of the country's milk supplies is certainly not satisfactory and that alterations are essential if improvements are to be brought about. It is definitely desirable that administrative machinery for the control of milk production and distribution should be strengthened although it is necessary to emphasise that there had been considerable improvement in the purity of milk supplies up to outbreak of the present war. Shortage of man-power and inadequate supplies of equipment and materials of all kinds have greatly increased the difficulties of both producers and distributors, while many persons have entered the liquid milk market who were previously butter- or cheese-makers, or who produced milk for manufacturing purposes only and who have been tempted to take this step by prohibition of farmhouse butter- and cheese-making and by the financial inducements offered. Their premises are generally unsuitable for this purpose and, on account of difficulties previously outlined, local authorities have been unable to secure the necessary alterations to buildings or provision of essential equipment.

From a public health point of view, the proposal to separate the production of milk from its distribution is considered in many quarters to be a retrograde step. Milk production is solely a commercial matter and purely an agricultural procedure. Provided that the control of designated milk consumed in its raw state is left with the public health authorities and that all other raw milk is efficiently pasteurised before sale no exception can be taken to this conclusion. It is a matter of paramount importance to public health that it is the duty of public health authorities and not that of any central body to see that the public milk supply is safe, clean, and that it possesses a proper nutritive value. Local Authorities should now concentrate on the distribution of a *safe* milk supply to the consuming public, leaving economic aspects of the milk problem to the central authority.

Essential Requirements for Improving the Milk Supply

Much of the criticism of the Government's milk policy as outlined in the White Paper has been destructive and, as improvement is urgently called for with a view to perfecting control of the production and distribution of milk, it is necessary to outline certain measures which would ensure a safe and health-giving milk supply for every consumer. The improvements necessary to attain this state of affairs should be carried out on the following lines:

(1) Legislation.
(2) Health of Milk-producing Herds.
(3) Routine Inspection of Cowsheds and Dairies.
(4) Improvements to Cowsheds and Dairies.
(5) Improvements in Handling Milk.
(6) Increased Laboratory Control.
(7) Compulsory Classification of Milk.

(1) Legislation

Legislation has done much to assist in improving the hygienic condition of our milk supplies and, at the moment, no further legislation is required with the exception of a new Milk and Dairies Order or Regulations of a similar nature, either of which is long overdue. The new legislation envisaged above should require particularly that the inspection of cowsheds and dairies at frequent intervals be obligatory instead of permissive as at present. The results of the present permissive legislation have been that many local authorities have not carried out their duties in a satisfactory manner. This laxity of the few has been directly responsible for the proposals set out in the White Paper previously mentioned, and for transference of the control of milk production to the central authority. The Milk and Dairies Order at present in force is far too indefinite to be of any considerable assistance and requires drastic amendment, particularly as regards sanitation and cleanliness. Its vague terms have resulted in considerable variation in the requirements of public health authorities, even in adjoining districts, and this has caused great dissatisfaction to both producers and distributors. No standards have been fixed which could be accepted by all concerned although these are definitely required. A clearly drafted standard for premises is an urgent necessity and this should include a very definite requirement for separate dairy or milkroom accommodation. Standardised requirements as to matters of cleanliness, water supply, cooling, storage, distribution and even handling of empty churns are needed urgently. While it must always be admitted that it is possible to produce clean milk in inferior buildings, it is obviously much easier to do so in accommodation where there is no necessity to be constantly overcoming difficulties and disadvantages, while well-constructed, light and airy buildings are of considerable benefit in maintaining the health of animals. A time limit ought to be fixed for the requisite works to be completed and loans or grants could be made to producers in order to assist them in bringing their accommodation up to the desired standard. A paramount need is a fixed standard for the cleanliness of milk, supported by penalty clauses for failure to comply. At first, such standard would, of necessity, be low, but as experience was gained it could be raised. In the past the milk producer was not always under the direct supervision of the authority in whose area the milk was consumed, and such authorities have had to rely, often with little satisfaction, upon the efficiency of the authority in whose area the milk was produced. This difficulty should now be overcome following centralised control of raw milk production but, in addition, all local authorities should be compelled to carry out their duties as regards milk distribution in a standardised and efficient manner. Before the commencement of the present war, some attempt had been made to consolidate the law relating to milk in conjunction with that for other foodstuffs, but recent years have seen amendment after amendment become operative until, at the present time, the position has reverted to that which existed a few years ago. The Government ought finally to decide exactly under what conditions they wish milk to be produced and distributed. Once their policy is settled, the existing legislation, which is primarily designed to protect the health of the consumer, should be finally clarified in order to provide for more efficient administration.

(2) Health of Milk-producing Herds

No measures of control will, in themselves, be satisfactory or sufficient unless they ensure eradication of tuberculosis from dairy herds together with the control of contagious abortion and streptococcal mastitis. The Attested Herd Scheme and the constant but slow increase in the number of tuberculin-tested herds only touches upon the fringe of the problem, and much more will have to be done before a solution is finally reached. Elimination of tuberculosis from dairy herds is a problem of considerable magnitude, but if a determined policy were followed it should be possible in time to require that all reactors to the tuberculin test should be slaughtered. It would not be feasible to take this drastic step immediately as the country cannot afford the loss of approximately 40 per cent. of its milking cows with a consequent reduction in the amount of milk available for human consumption In spite of this, all animals should be tuberculin tested at an early date to be followed by a biological examination of the milk from reactors. Those animals giving tuberculous milk should be immediately slaughtered. The remainder of the reactors should be kept under constant observation and any deterioration in health should be noted, while the milk of such animals should also be subjected to frequent biological examinations in order to ensure its freedom from tubercle bacilli. In this way, animals could be controlled until they were due for slaughter.

Bulls should not be overlooked, and all those reacting to the tuberculin test should be slaughtered while only calves from cows which have passed the test should be reared for milk production or breeding purposes. In this way, the dairy stock of the country would be improved. Every producer should be required to keep a herd register which would show all additions and removals from his herd while all cattle should be suitably marked for the purpose of identification. If this policy were adopted, animals affected with tuberculosis would be able to provide milk during the transitional period while the milk from reactors would, of course, be heat-treated. Further, strenuous efforts should be made to eliminate contagious abortion from dairy herds by means of inoculation while measures for the control of mastitis in all herds are urgently needed.

There does not appear to be any reason why the veterinary profession should not be able to carry out the complete elimination of these uneconomic and dangerous diseases and it is to be regretted that it has not, up to the present, been possible to make any rapid strides in abolishing disease from dairy herds. It must be admitted, however, that enormous difficulties face the veterinarians and, given Governmental assistance, their time could be much better spent in improving the general health of milk-producing cattle of this country, rather than attempting to deal with other aspects of the milk problem. The country cannot afford to allow highly-trained veterinary surgeons to waste their time supervising matters which can be more efficiently carried out by experts in other fields.

Apparently, increased inspections, so vitally necessary, cannot be carried out, for the White Paper previously mentioned suggests the annual inspection of all dairy herds. This period between inspections is far too great if animal health is to be radically improved and milk supplies rendered safe and it is essential that a thorough clinical inspection of every dairy cow in the country should be made at quarterly intervals. This is the ideal to aim at although it is obvious that there is a serious shortage of veterinary surgeons. Many counties did little in this direction and even the transfer of veterinary inspection to the Minister of Agriculture and Fisheries will not assist in the eradication of animal disease unless a bold policy is pursued. It must be remembered that lackadaisical methods regarding improvement of animal health may mean, at least, loss of life to the consumer or, at any rate, much ill health.

(3) Routine Inspection of Cowsheds and Dairies

In order to ensure that milk is produced and distributed in a cleanly manner, much more inspectorial work is necessary, particularly at the point of production. Such work could not possibly have been carried out by existing staffs, especially those to be found in rural areas, who have had, in addition to milk control work, multifarious duties to perform. Apart from the detection of unsatisfactory premises and methods, a considerable amount of valuable educational work can be achieved by competent inspectors, provided there are a sufficient number to cover the field. Spasmodic inspections of farm premises without the necessary re-visits to follow up are of little use. Continuous effort is essential if progress is to be achieved. In the majority of rural districts where the bulk of milk is produced, the present staffs, even when they are fully conversant, as they must be, with modern methods of hygienic milk production, have been entirely inadequate to deal with the problem. Many of the critics of present methods of inspection are living in non-milk producing areas and do not realise the difficulties which are experienced in maintaining the constant inspection service they so glibly demand. Hitherto, the entire expense of supervising milk production has fallen mainly on the rural authorities who have generally carried out a difficult task in an extremely satisfactory manner. At no time have contributions towards the cost been offered by non-producing areas so that a better system of inspection could be carried out. Now the supervision of milk production will rest with the officials of the Ministry of Agriculture and Fisheries, although, if veterinary inspectors are employed to carry out routine inspections, as has been suggested, it is difficult to see how the position can be improved. There is just as great a shortage of qualified veterinarians as there is of sanitary inspectors and the appointment of a sufficient number of milk and dairies inspectors at salaries commensurate with their responsibilities therefore becomes a definite necessity under the new powers granted to the Minister of Agriculture and Fisheries.

(4) Improvements to Cowsheds and Dairies

An immediate programme of reconstruction for existing cowsheds is essential. Many of the buildings at present used for housing dairy herds should be treated as dilapidated houses have been in the past and be subject to demolition. While a large number of unsatisfactory buildings may be considerably improved by reconstruction and adaptation, many existing cowsheds, if allowed to remain standing, will perpetrate unsatisfactory conditions for the production of milk, and other difficulties. In such cases, new erections should be considered essential. For this purpose, the development of a unit or pre-fabricated system of construction for farm buildings is worthy of investigation. Greater use should be made of milking parlours or milking bails, the latter being either portable or permanent as desired. In any scheme of reconstruction, attention should be paid to site, water supply, standing, drainage channel, ease of cleansing and removal of manure. To finance this essential work, money should be loaned to occupiers, to be repaid by easy instalments over a specified period.

(5) Improvements in Handling Milk

Advisory and control work in connection with milk production and distribution should continue unabated and particular attention should be paid to milk cooling. Few public water supplies possess a sufficiently low temperature to be of any value for this purpose, particularly during summer months, and supplies from deep wells, usually suitable, are not always available. Acquiescence to lack of cooling by bulk purchasers of milk has resulted in many producers ceasing to cool their product and in this lies a grave danger, for the whole of the subsequent handling and treatment of milk after production is based on the assumption that milk has been adequately cooled. A cheap and simple form of refrigerating cooler is an urgent necessity and *cooling should be compulsory under all circumstances*. Co-operative cooling stations where milk could be brine-cooled are worthy of consideration, not only to improve keeping quality of milk but also as a means of saving transport and conserving water supplies, particularly in rural areas. Such stations could be set up either by milk producers or by the purchasers. Of considerable importance, particularly at the present time, are the delays which occur in collection of milk from farms. These delays, often amounting to many hours, result in a milk of poor keeping quality reaching the place of treatment, while further delays in handling are due to the present policy of over-centralisation. Large treatment centres are forced to deal as best they can with an article which is often uncooled, badly stored at the roadside, and delayed in transit. Provision of better transport facilities should not be beyond attainment.

(6) Increased Laboratory Control

In conjunction with adequate inspectorial visits, a considerable extension of laboratory control is called for. By such means it would be possible to ensure an adequate check upon methods of production and handling. Standardisation of laboratory technique is essential and samples of raw milk should invariably be examined before and after laboratory pasteurisation. A bacterial count in milk so treated equalling that of the milk prior to treatment in the laboratory should be taken as an indication of the presence of heat-resistant organisms, due to inefficient sterilisation of the utensils. A compulsory standard of cleanliness and keeping quality for all raw milk should also be prescribed.

(7) Compulsory Classification of Milk

Compulsory classification of all milk supplies is an urgent necessity, not only as forecast, for certain specified areas, but in every district throughout the country and this classification should remain in force until such time as all diseases pathogenic to man are eradicated from dairy herds. This compulsory classification should not, however, be brought about by addition to the Defence (General) Regulations, 1939, but by a slight amendment of existing legislation and by drafting of Milk Regulations to be adopted by a local authority with the consent of the Minister of Health. It should always be remembered that a *safe* milk supply is essentially a public health matter. Such suggested Regulations should :

(*a*) Classify all milk in accordance with any Designation Order in force at the time.

(*b*) Require that all milk be pasteurised, except when produced from tuberculin-tested animals.

(*c*) Require that all milk should be delivered in sealed, sterilised bottles.

If such powers were provided the public could be assured of obtaining a safe article for which they would naturally be expected to pay an economic price.

The price of milk has been the cause of considerable agitation in the past and there is abundant evidence to show that the constitution of the Milk Marketing Board saved the industry from chaos, as prices were at that time on the point of collapse. The Board warded off the threat of ruin, every producer being assured of a market for his milk, although in every instance the price obtained did not satisfy everyone. Some years ago, the Consumers' Committee of the Milk Marketing Board stated that retail prices were too high and, for a great deal of the milk, this was no doubt true. Since the present war commenced, prices have risen still higher and supplies have become shorter. No one has grumbled at the price but only at the scarcity of the product and the psychology of the consuming public must always receive consideration. If milk was plentiful and unrationed, as in normal times, any reduction in price would almost certainly arouse suspicion in the minds of the consuming public and might easily defeat the object in view. In times of peace, there is little doubt that a clean, safe milk could be sold at 9*d*. per quart without any loss to the producer or distributor, and with advantage to the consumer. Much would, of course, depend upon the legal requirements specified for such milk. If the producer and distributor are forced, as undoubtedly they should be, to supply the public with a clean and safe milk, they should receive a fair price for their product. If they cannot provide such an article, they should be debarred from the profits of the liquid milk market. The policy of selling poor-quality milk of doubtful safety at low prices is disastrous and should never be countenanced.

Lowering the price of milk is not likely to increase consumption to any marked degree *until the public cease to be dubious as to its safety*, When the medical profession are in a position to state that *all* the milk supplied in this country is safe and reliable, then and only then can the public be expected to consume large quantities and be willing to pay the price which the quality of such milk demands. Although the average raw milk as at present supplied is expensive by virtue of its poor hygienic quality, it can never be expected that the producer of *efficiently* pasteurised milk will be willing to accept a low price for his product, particularly when such milk can be guaranteed free from any harmful properties. Until the producer or distributor can provide such a safe and reliable article, no amount of advertising is likely to increase the consumption of milk to any appreciable extent, while any reduction in price would still remain a doubtful blessing.

The suggestions outlined above have been more fully dealt with in the preceding chapters and would, it is earnestly believed, be of considerable assistance in " cleaning-up " the nation's milk supply. For this reason, they are submitted for the consideration of all who are interested in the hygienic quality of milk produced in this country. It is to be hoped that a point will eventually be reached when all milk will be clean and safe, will be delivered in sealed, sterile bottles, and will be sold at a price which the consumer can afford and which will allow the producer and distributor a fair margin of profit. In other words, the ultimate aim should be " *One Grade—One Price*."

APPENDIX I

FORMS OF LICENCE UNDER THE MILK (SPECIAL DESIGNATIONS) ORDER, 1936

Form A

Milk (Special Designations) Order, 1936

Producer's Licence authorising the use of the special designation "Tuberculin Tested"[1] in respect of a farm at which the milk is (not)[2] bottled

The.. hereby authorise ....of.............................to use the special designation "Tuberculin Tested" in relation to milk produced from a herd at ....in accordance with the conditions prescribed in the Milk (Special Designations) Order, 1936 (and sold or intended for sale by wholesale)[2].

This licence is not transferable and is subject to conditions prescribed in the above-named Order, and unless suspended or revoked will operate until the 31st day of December, 194 .

(This licence does not authorise the holder to use the above-named designation in relation to milk sold outside the area of the licensing authority except in relation to milk sold by wholesale).[3]

Dated this.............day of ....194 .

Clerk to the County Council.
Town Clerk.

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[1] A similar form with appropriate modifications is to be used for licences for the use of the special designation "Accredited."

[2] Strike out the words where the milk is bottled at the farm.

[3] Strike out this paragraph where the milk is not bottled at the farm.

Form B

Milk (Special Designations) Order, 1936

Dealer's Licence authorising the use of the special designation "Tuberculin Tested."[1]

The......................................hereby authorise ....of.........................(referred to herein as the dealer) to use the special designation "Tuberculin Tested" in relation to milk which is obtained by the dealer (as "Tuberculin Tested" from an establishment in respect of which a licence authorising the use of that designation in relation to it is in force, which is bottled by the dealer at ....and which is sold or intended for sale at or from that address)[2] (in bottles as " Tuberculin Tested " from an establishment in respect of which a licence authorising the use of that designation in relation to it is in force and is sold or intended for sale at or from........ ....)[2]

This licence is not transferable and is subject to the conditions prescribed in the Milk (Special Designations) Order, 1936, and unless suspended or revoked will operate until the 31st day of December, 194 .

This licence does not authorise the holder to use the above-named designation in relation to milk sold outside the area of the licensing authority except in relation to milk sold by wholesale.

Dated this.............day of ....194 .

Clerk to the County Council.
Town Clerk.

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[1] A similar form with appropriate modifications is to be used for licences for the use of the special designation " Accredited " and for the use of the special designation " Pasteurised " in relation to milk sold by a dealer at or from an establishment not covered by a licence in Form C.

[2] Strike out whichever words are not applicable.

FORM C

Milk (*Special Designations*) *Order* (*Regulations*), 1936 (*to* 1941)[1]

Pasteuriser's Licence authorising the use of the special designation " Pasteurised "

The.. hereby authorise ....of...................to use the special designation " Pasteurised " in relation to milk treated by the pasteurising process at.........................in accordance with the conditions prescribed in Milk (Special Designations) Order (Regulations), 1936 (to 1941)[1].

This licence is not transferable and is subject to the conditions prescribed in the above-named Order (Regulations),[1] and unless suspended or revoked will operate until the 31st day of December, 194 .

This licence does not authorise the holder to use the above-named designation to milk sold outside the area of the licensing authority except in relation to milk sold by wholesale.

Dated this.............day of.............194 .

Clerk to the...........Council.
Town Clerk.

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[1] As a person applying for a licence (other than the renewal of an existing licence) to use the special designation " Pasteurised " must indicate in his application whether such application is for licence to be granted under the Order of 1936, or under the Regulations of 1941 (High-Temperature, Short-Time process), the words above may be left in or struck out as desired.

FORM D

Milk (*Special Designations*) *Order*, 1936

Supplementary Licence authorising the use of the special designation " Tuberculin Tested."[1]

The..hereby authorise ....of...................being the holder of the licence (referred to herein as the principal licence) dated .... and granted by..............................to which this supplementary licence is appended,[2] to use the special designation "Tuberculin Tested" in the...........................[3] in relation to milk to which the principal licence applies and which is sold by retail from the premises specified in that licence.

This supplementary licence is subject to conditions prescribed in the Milk (Special Designations) Order, 1936, and unless suspended or revoked will operate during the period of operation of the principal licence.

Dated this..............day of..............194 .

Clerk to the..............Council.
Town Clerk.

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[1] A similar form with appropriate modifications is to be used for supplementary licences for the use of other special designations.

[2] If preferred the licence may be endorsed on the principal licence.

[3] Insert name of the district.

FORM OF NOTICE REQUIRING A PERSON SUFFERING FROM TUBERCULOSIS OF THE RESPIRATORY TRACT TO DISCONTINUE HIS EMPLOYMENT

The Public Health (Prevention of Tuberculosis) Regulations, 1925

To...........................

of...........................

The..............................., being satisfied on the report of their medical officer of health that you are engaged in an employment or occupation involving the milking of cows, the treatment of milk, or the handling of vessels used for containing milk in connection with a dairy and that you are suffering from tuberculosis of the respiratory tract and are in an infectious state, hereby give you notice that you are required on or before the........ day of................194 ., to discontinue such employment or occupation.

Dated this..............day of..............194 .

Signature of Clerk or
Medical Officer of Health.................

Note. Any person sustaining damage by reason of the exercise by a Local Authority of any of the powers of these Regulations and not being himself in default, is entitled to receive full compensation from the Local Authority. Any claim which you desire to make should be addressed in writing to the Clerk to the Council.

You are entitled, within fourteen days after the service of this notice, to appeal to a Court of Summary Jurisdiction against the Local Authority's decision requiring you to discontinue your employment. If you intend to appeal, you must give notice in writing to the Clerk to the Council of your intention and of the ground of the appeal.

SPECIMEN FORMS AND CARDS FOR USE UNDER THE MILK AND DAIRIES ORDER, 1926

Form 1

BOROUGH OF....................

Food and Drugs Act, 1938 *and Milk and Dairies Order,* 1926

Application for Registration as a Cowkeeper, and/or Dairyman, and/or Wholesale Purveyor of Milk

To..........................Council of..........................

I HEREBY give you Notice that I (propose to carry on) (carry on) the trade of[1]..
at premises..
in the parish of..............................within your district,
and comprising[2]..
....
and I hereby apply to the Council to be registered accordingly, in compliance with the above-mentioned Act and Order.

(Signature) ....
Address..........................
....

Dated this.............day of.............194..

Note. One month's notice is required before commencing to use any premises not previously used, as a cowshed or place for the storage of milk.

[1] Fill in the trade proposed to be carried on as required.

[2] Give here a brief description of the premises.

For Official Use.

No. ....
Inspected ....
Reported......................
Registered ....
Certificate No. ....

Form 2

BOROUGH OF.....................

Food and Drugs Act, 1938 *and Milk and Dairies Order,* 1926

Application for Registration as a Retail Purveyor of Milk

To..........................Council of..........................

I HEREBY give you Notice that I (propose to carry on) (carry on) the trade of a Retail Purveyor of Milk at premises..........................
....
in the parish of..............................within your district
and comprising [1]..
....
and I hereby apply to the Council to be registered accordingly, in compliance with the above-mentioned Act and Order.

(Signature) ....
Address ....
....

Dated this.............day of...............194 .

[1] Give here a brief description of the premises.

For Official Use.

No. ....
Inspected ....
Reported......................
Registered ....
Certificate No................

FORM 3

BOROUGH OF......................

Food and Drugs Act, 1938 *and Milk and Dairies Order,* 1926

Application for Registration of Premises as a Dairy

To..........................Council of..........................

I HEREBY give you Notice that I (propose to use) (use) as a Dairy, the premises situate.. in the parish of................................ within your district and comprising[1]..
....
and I hereby apply to the Council for the registration of the said premises as a Dairy, in compliance with the above-mentioned Act and Order.

(Signature) ....
Address ....
....

Dated this..............day of................194..

Note. One month's notice is required before commencing to use any premises not previously used, as a cowshed or place for the storage of milk.

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[1] Give here a brief description of the premises.

For Official Use.

No. ....
Inspected ....
Reported......................
Registered ....
Certificate No................

SPECIMEN HEADINGS FOR REGISTER OF COWKEEPERS AND RETAIL PURVEYORS

Register of Cowkeepers and Wholesale Purveyors

Number.
Registration : Date.
Number.
Name of Occupier.
Situation of Premises.
Name of Owner.
Description of Premises.
Lighting.
Ventilation.
Water Supply.
Drainage System and Disposal.
Number of Cows.

Number and Cubic Contents of each Cowshed.
Storage of Milk.
Sterilisation of Utensils.
Grade of Milk Sold.
System of Heat-treatment.
Remarks.

Register of Retail Purveyors

Number.
Registration : Date.
Number.
Name of Occupier.
Situation of Premises.
Name of Owner.
Description of Premises.
Lighting.
Ventilation.
Water Supply.
Drainage System and Disposal.
Storage of Milk.
Washing and Sterilisation of Utensils.
Grade of Milk Sold.
System of Heat-treatment.
Remarks.

FORM OF CARD FOR MILKSHOP INSPECTION

MILKSHOP INSPECTION

No on Register .... Address......................
Date of Visit ....

Occupier...................... Owner.........................
Source of Milk Supply...

Storage of Milk.	Vessel Used.	Cleanliness.

Possible Sources of Contamination.............................
Drainage..
Water Supply..
General Condition of Premises ....
P.T.O.

(Reverse side for revisits and conditions found.)

FORM OF CARD FOR COWSHED OR DAIRY INSPECTION

Cowshed or Dairy Inspection

No. on Register...............	Address........................
Date of Visit	....
Date of Registration...........	Occupier ....

Cubic Capacity of Shed (1)..........	Source of Milk............
Do. (2)..........	Supply ....
Cows Allowed (1).................	Utensils : Kind ....
(2).................	Cleansing ....
Manure	Storage ....
Water Supply.....................	Water Supply ....
Washing Accommodation	Cooler ....
Overalls for Milkers...............	Remarks ....
Other Matters....................	....

Drainage......................	Ventilation ....
Floors	Walls......................
Lighting : Artificial............. Natural	Ceilings ....

Other Matters ....

P.T.O.

(Reverse side for revisits and conditions found.)

Form 4

BOROUGH OF.......................

Food and Drugs Act, 1938 *and Milk and Dairies Order*, 1926

Certificate of Registration

I hereby certify that...
of ....
carrying on the trade of [1]..at
....
in the Parish of...
in the...............................of.............................
is Registered as such under the above-mentioned Act and Order.
Dated this...................day of.................194 .
Signature..........................
Town Clerk.

---

[1] Fill in here the trade to be carried on as required.

Schedule

Address of Premises.	Description of Premises.

SPECIMEN FORMS AND HEADINGS FOR NOTEBOOKS UNDER THE FOOD AND DRUGS ACT, 1938

Label for Sample Bottle

The following particulars are essential :

(1) Name of Authority.
(2) Number of Sample.
(3) Description of Sample.
(4) Name of Sampling Officer.
(5) Date.

Headings for Page in Sampling Notebook

(1) Name of Authority.
(2) Number of Sample.
(3) Description of Sample.
(4) Date of Purchase and Price paid.
(5) Time of Purchase.
(6) Name of Person selling the Article.
(7) Name and Address of Employer of such Person.
(8) Remarks.

Samples taken in Transit or during Course of Delivery

The following particulars should be recorded in the case of samples of milk taken in transit or during course of delivery to a retailer :

(1) Number of Sample.
(2) Description of Sample.
(3) Churn Number.
(4) Gallons in Churn.
(5) Time of Arrival.
(6) Consignor, with address.
(7) Consignee.
(8) Particulars of Label on Churn.

The label on the churn should always be endorsed with the word "sampled," and the number and date of the sample, together with the initials of the person taking the sample, should be inscribed thereon. Where the cows are milked under supervision of the sampling officer and a sample of milk is taken immediately after milking the sample submitted to the analyst should be marked "Appeal to the Cow Sample."

Food and Drugs Register

The following headings are essential :

(1) Sample Number.
(2) Date of Purchase.
(3) Name of Purchaser.
(4) Name and Address of Seller.
(5) Article Purchased.
(6) Amount Paid.
(7) Result of Analysis.
(8) Date of any Proceedings.
(9) Fines.
(10) Costs.
(11) Remarks.

Samples Taken during Course of Delivery by Rail

When milk is taken during course of delivery at a railway station, one portion of the sample should be delivered to the farmer who sent the milk. This should be forwarded by registered post, accompanied by the following form :

Borough of ....
Public Health Department.
..........194 .

SIR.—

I have this day, under the Food and Drugs Act, 1938, procured in the course of delivery, at .... Railway Station, a sample of milk in transit, and consigned by you to ....by a train arriving at..................................from a churn numbered ....which contained........gallons.

It is my intention to submit same to the Public Analyst to be analysed. I have this day forwarded to you by registered post a portion of the sample above referred to, marked No....... and duly sealed with the official seal.

Yours faithfully,

....
Inspector.

To..................................
....
....

APPENDIX II

SUGGESTED PROPAGANDA BULLETINS

Bulletin No. 1

Suitable for Producers and Distributors

INTRODUCTION

MILK is the natural food of many animals for varying periods after birth, and contains the constituents of a standard diet in proportions most favourable for the growth and development of the young animal.

COW'S MILK may be defined as the normal secretion of the udder of a healthy cow and as such contains a negligible number of bacteria of a harmless character.

The value of fresh milk as an article of food is well known, more particularly for infants, the aged and the sick. It is of the utmost importance that milk should be removed from the cow and delivered to the consumer with the addition of the minimum amount of dirt. In other words, milk should be kept clean through all stages from actual milking of cow to the delivery of the milk to the consumer.

"Clean Milk" and "Dirty Milk"

CLEAN MILK may be defined as raw whole milk from healthy cows, which has a minimum number of bacteria and which is capable of keeping sweet for a reasonable length of time, at least two days, whatever variations in temperature occur.

The word "DIRT" as applied to milk does not necessarily imply only those substances which in everyday life are included under that term. DIRT as applied to milk means rather the presence of BACTERIA in the product. BACTERIA are micro-organisms of varying types, which are so minute that it is necessary to use a microscope of high power before their presence can be detected. Some idea of the size of these microscopic forms of life may be gathered when it is remembered that it takes approximately 25,000 of them placed in a row to measure an inch, that is, to stretch across a halfpenny.

It is not possible to exclude all bacteria from milk, but it is possible to reduce to a minimum the number which may gain access.

It is also necessary to exclude all large particles of dust and dirt which may gain entrance to milk and which are usually removed by the process of straining. It must be emphasised, however, that the bacteria to which reference has been made, and which alone are responsible for milk turning sour, are so minute that they will pass with ease through the finest material used as a straining cloth or pad. Farmers often state that they strain their milk regularly, and, in fact, results of such straining may be demonstrated, *but it must be clearly understood that the most important part of the dirt, namely the bacteria, has passed through the strainer and remained with the milk.*

ONCE MILK CONTAINS DIRT IT IS IMPOSSIBLE TO REMOVE IT AND MAKE THE MILK CLEAN AGAIN.

Milk must, of course, be strained, but mere straining does not remove bacteria, which must not be allowed to enter milk.

Milk: What it is

Milk consists of a number of substances in varying proportions, an average analysis being as follows:

	Per cent.
Water	87·20
Milk Fat	3·90
Protein	3·40
Milk Sugar	4·75
Mineral Matter	0·75

Milk fat is that portion of milk concerned in the making of butter. The *proteins* consist of substances known as casein and lactalbumen, which are concerned in the making of cheese. *Milk sugar* consists of a substance known as Lactose.

Sour Milk

Everyone is aware that milk " turns sour," becoming semi-solid and acid. Milk may be drawn from the udder of the cow and kept in sealed vessels for weeks without any apparent change. The cause of souring of milk is therefore some external agent introduced into milk after it leaves the cow. This external agent consists of bacteria such as have been previously described. These bacteria act upon Lactose and produce Lactic Acid. Curdling of the Casein subsequently occurs and the action of souring is complete.

One of the chief objects of clean milk production is to prevent the entrance of bacteria into milk which will be likely to cause it to turn sour. Such an object is one of vital economic importance to the trade of milk producers as a whole, because souring of milk is responsible for considerable financial loss.

Bacteriological Examination of Milk

In order to ascertain whether or not milk is clean, it must be examined for the presence of bacteria. Milk is examined bacteriologically in two ways, as follows:

(1) For bacterial content and the presence of the *Bacillus coli*: and
(2) For the presence of tubercle bacilli.

Bacterial Content as indicated by the total bacterial count, the methylene-blue reductase or the resazurin tests, shows whether or not the milk is clean. The number of bacteria may vary within a very wide range. There may be only a few hundreds or less per millilitre, or there may be many millions in a similar quantity. When we consider that the volume of a millilitre is smaller than an average lump of sugar, the presence of millions or even of hundreds of thousands of bacteria in such a small amount is very unsatisfactory.

No maximum has been fixed for the bacterial content of ordinary raw milk, but some indication of the standard to be aimed at may be given by referring to the conditions applicable to Designated Milks permitted under the Regulations of the Ministry of Health.

It should be the aim of every farmer to produce milk containing not more than 200,000 bacteria per millilitre. Such milk would have no difficulty in complying with the requirements of the methylene-blue reductase or resazurin tests.

In addition to the bacterial content, the presence or absence of a special type of bacteria is also determined. This organism is known as BACILLUS COLI, and represents a group of bacteria which are normally present in the stomach and intestinal canal of the cow, and which are passed from the animal in its dung. These organisms may also be present as a result of inefficient sterilisation of utensils. The presence of these bacteria in milk is therefore a definite indication either of excremental contamination or of unsatisfactory cleansing of the milk vessels. Every effort should be made to prevent the entrance of the *Bacillus coli* into milk, and IT OUGHT NEVER TO BE PRESENT IN A SMALLER AMOUNT THAN ONE-TENTH OF ONE MILLILITRE.

The question of tuberculosis in cows and the presence of tubercle bacilli in milk will be considered in the third bulletin. Sufficient here to say that all cows giving tuberculous milk must be excluded from the herd and promptly slaughtered. It must be remembered that it is an offence, liable to heavy penalties, to sell milk containing the organisms of tuberculosis.

Clean Milk Production

In the past too much attention has been paid to the structural condition of cowsheds wherein cows are housed for the greater part of the year, to the almost total disregard of methods employed in the control of milk from the moment it leaves the cow. Without in any way under-estimating the importance of good cowsheds, it may be definitely stated that clean milk production depends much more upon methods adopted in its collection and distribution than upon the possession of elaborate buildings. Much clean milk in this country is being produced in buildings which are structurally very unsatisfactory and capable of great improvement.

CLEAN MILK DEPENDS ALMOST ENTIRELY UPON METHODS EMPLOYED IN ITS PRODUCTION, CHIEF AMONG WHICH IS THE QUALITY OF LABOUR NECESSARY IN THE VARIOUS OPERATIONS.

Clean Milk Production

MILK AS IT LEAVES THE HEALTHY COW IS ALWAYS CLEAN.

DIRTY MILK IS DUE TO THE ADDITION OF BACTERIA AFTER MILK LEAVES THE COW.

SOUR MILK IS DUE TO BACTERIA FORMING LACTIC ACID.

DIRTY MILK SOON BECOMES SOUR MILK, WITH FINANCIAL LOSS TO THE FARMER.

NO MILK SHOULD CONTAIN MORE THAN 200,000 BACTERIA PER MILLILITRE.

BACILLUS COLI SHOULD NEVER BE PRESENT IN A SMALLER QUANTITY OF MILK THAN ONE-TENTH OF A MILLILITRE.

MILK CONTAINING TUBERCLE BACILLI SHOULD NEVER BE SOLD.

METHODS ARE MORE IMPORTANT THAN BUILDINGS.

CHIEF AMONG METHODS IS THE QUALITY OF LABOUR EMPLOYED.

METHODS SHOULD ALWAYS
COME FIRST

Bulletin No. 2

Suitable for Producers

THE COWSHED

The importance of a satisfactory building for use as a cowshed cannot be over-estimated. At the same time a good building is by no means the only necessity for the production of clean milk. In the past too much attention has been paid to the structural condition of cowsheds with an almost total disregard for methods employed in the production of milk. Given a cowshed of only moderate construction, it is possible to produce clean milk *consistently*, PROVIDED REGULAR ATTENTION IS PAID TO THE CLEANLINESS OF THE COWSHED in addition to other points dealt with in these Bulletins. The following points in connection with the cowshed should be noted.

The Floor

The floor of the cowshed, which should be of impervious material, preferably concrete, must be kept scrupulously clean. It is essential that all dung, etc., should be removed from the cowshed AT LEAST ONCE EACH DAY. Dung must not on any account be moved immediately before milking, as the action of moving this material causes the production of dust and dirt which is liable to enter and contaminate the milk. The dung channel should be sufficiently wide to permit liquid to flow off at the back to the drain inlet outside the cowshed, and it must be kept as clean as possible to enable this to occur. Dung, etc., should be removed to a point as far away from the cowshed as possible. The practice of tipping dung in a heap in close proximity to the building cannot be too strongly condemned.

The Walls

It is equally important that the walls of the cowshed should be kept thoroughly clean. Whenever possible they should be rendered in cement to a height of 4 ft. 6 in. to enable this to be readily carried out. In all cases the whole of the walls and roof in the cowshed must be thoroughly cleansed and limewashed as often as is necessary and NOT LESS FREQUENTLY THAN TWICE IN EACH YEAR, once during April or May and once during September or October. It is advisable to add a small quantity of disinfectant to the lime when making limewash.

The Roof

In many old cowsheds the roof is far from satisfactory. Cobwebs and dust are frequently found accumulated in the roof, forming a constant source of contamination to milk. All parts of the roof must therefore be kept scrupulously clean and frequently limewashed.

Troughs, Partitions, and Yokes

It is also important that feeding-troughs, divisions between stalls, and yokes are kept absolutely clean. They are often found in a filthy condition, particularly the divisions. As these divisions are often made of wood, which at best is a very unsatisfactory material for this purpose, they require constant attention and must be cleansed and limewashed frequently.

Lighting

In many cases cowsheds are so dark, even in the middle of the day, that it is impossible to see sufficiently well to keep them clean. In every case the cowshed must be provided with a sufficient number of openings to light every part of the interior of the building effectively, and SUCH OPENINGS MUST BE MAINTAINED IN GOOD ORDER AND NOT IN ANY WAY OBSTRUCTED OR SCREENED. In addition to natural light, it is essential that GOOD ARTIFICIAL LIGHT BE PROVIDED for use during winter months. The old type of lamp is often unsatisfactory, requiring constant attention and not giving a sufficiently bright light. Any of the modern paraffin vapour lamps now on the market will be found both efficient in use and economical in cost if electricity is not available.

Ventilation

This is one of the most important items in connection with the management of the cowshed. Ventilation has a marked influence on the health of the cows and indirectly on the quality of the milk. In cowsheds where there is practically no ventilation and the atmosphere is hot and stuffy, the vitality of the animals is considerably reduced and they are rendered more susceptible to disease. The practice of stopping up air inlets and outlets with straw, etc., to keep the cowshed " warm " cannot be too strongly condemned. It is certainly necessary to protect animals from EXCESSIVE COLD, but it is equally necessary to protect them from excessive heat. It has been repeatedly demonstrated in practice by farmers themselves that cows can withstand wide variations in temperature without any adverse effect upon their health OR UPON THE MILK YIELD. Speaking generally, each cow requires 600–800 cubic feet of free air space. ADEQUATE AND PERMANENT MEANS OF VENTILATION ARE, HOWEVER, OF INFINITELY GREATER VALUE AND IMPORTANCE THAN MERE PROVISION OF CUBIC AIR SPACE. Unless provision is made for regular renewal of the air in the cowshed, it will become foul and contaminated, whatever amount of free air space is provided.

Water Supply

It is impossible to cleanse a cowshed adequately without a plentiful supply of CLEAN WATER. In addition, an abundant supply of wholesome water is necessary for watering the cattle. Whenever possible, water should be laid on to the cowshed itself, particularly as it is required for grooming cows and for washing the hands of milkers.

Drainage

Effective drainage of the cowshed is very important. The gully upon which drainage from the cowshed discharges is often found choked. These drain inlets require constant attention, and a grid should be provided to prevent the entrance of large solids which are liable to choke the drain.

The rules given above, governing the care of the cowshed, are all simple in application but make a considerable difference in the production of clean milk. Failure to comply with any one of them almost invariably results in contamination of the liquid.

Clean Milk Production—The Cowshed

REGULAR ATTENTION TO THE CLEANLINESS OF THE COWSHED IS ABSOLUTELY ESSENTIAL FOR THE PRODUCTION OF CLEAN MILK.

ALL DUNG MUST BE REMOVED AT LEAST ONCE EACH DAY.

DUNG MUST NOT BE REMOVED IMMEDIATELY BEFORE MILKING.

DUNG MUST BE REMOVED AS FAR FROM THE COWSHED AS POSSIBLE.

THE WALLS, DIVISIONS, ROOF, ETC., OF THE COWSHED MUST BE CLEANSED AND LIMEWASHED AT LEAST TWICE A YEAR.

WINDOWS AND OTHER OPENINGS PROVIDED FOR LIGHTING MUST BE MAINTAINED IN GOOD ORDER AND IN NO WAY SCREENED.

SUFFICIENT ARTIFICIAL LIGHT MUST BE PROVIDED.

VENTILATION OF THE COWSHED IS OF THE GREATEST IMPORTANCE.

EXCESSIVE HEAT IS AS HARMFUL AS EXCESSIVE COLD.

VENTILATION OF THE COWSHED IN NO WAY AFFECTS THE YIELD OF MILK.

ADEQUATE AND PERMANENT MEANS OF VENTILATION ARE MORE IMPORTANT THAN MERE PROVISION OF CUBIC SPACE.

AN ADEQUATE SUPPLY OF WHOLESOME WATER IS ESSENTIAL.

THE DRAINAGE ARRANGEMENTS OF THE COWSHED MUST BE KEPT IN GOOD ORDER.

THE CLEANLINESS AND VENTILATION
OF THE COWSHED
ARE OF THE GREATEST IMPORTANCE

Bulletin No. 3

Suitable for Producers

THE COW

Diseases of the Udder

IT IS IMPOSSIBLE TO PRODUCE CLEAN MILK UNLESS ALL THE COWS IN THE HERD ARE HEALTHY.

The milk supply is chiefly affected by diseases of the udder. It is necessary to examine the udders of all milking cows regularly and carefully in order to secure the early detection of any abnormality or disease which may adversely affect the quality of milk or render it dangerous for human consumption.

Inflammation of the udder or MASTITIS may be divided into two groups: (1) ordinary mastitis, and (2) tubercular mastitis. The chief points of difference between the two groups are as follows:

(1) *Ordinary Mastitis*

The quarter affected is hot, painful, and enlarged. The disease commences suddenly. If treated satisfactorily, inflammation subsides in a few days, after which the gland contains thick, pus-like matter. Milk may contain blood, be flaky or clotted, thick, slimy, or purulent. The affected quarter is often lost.

(2) *Tubercular Mastitis*

The quarter affected is cold and painless. There is no history of acute inflammation. The quarter very gradually increases in size and hardness and is often lumpy. MILK MAY APPEAR NORMAL.

It will be seen from the above brief summary that the chief points of difference between the two conditions is that in ORDINARY MASTITIS, THE AFFECTED PART OF THE UDDER IS HOT AND PAINFUL AND ONSET IS SUDDEN, whilst in TUBERCULAR MASTITIS THE AFFECTED PART IS COLD AND PAINLESS AND ONSET IS GRADUAL. The fact that the milk from a tubercular udder may be normal in appearance should never be forgotten.

It is of the utmost importance that a qualified veterinary surgeon should be immediately consulted on the first appearance of any abnormality in a cow's udder. The condition may only be slight and yield to early treatment and no permanent ill-effects result, but if neglected it may mean the loss of a quarter and consequent reduction in yield of milk with financial loss to the farmer.

Any person possessing a cow suffering from tuberculosis or suspected to be suffering from this disease, including tuberculosis of the udder, must immediately notify the fact to the local authority administering the Contagious Diseases of Animals Acts, in order that the animal may be dealt with under the Tuberculosis Order, 1938. This Order provides for the slaughter of all animals suffering or suspected to be suffering from tuberculosis, payment of compensation being made to the owner based upon the market value of the animal.

THE TUBERCULOSIS ORDER SHOULD REMOVE ANY FEAR OF FINANCIAL LOSS TO THE FARMER RESULTING FROM THE DISCOVERY OF AN ANIMAL AFFECTED BY TUBERCULOSIS IN HIS HERD.

The early removal of affected animals will prevent spread of disease to the other members of the herd. Under the Food and Drugs Act, 1938, it is provided that a person who sells milk from an animal known to be suffering from tuberculosis of the udder or from other specified diseases set out in that Act, shall be liable to a penalty. In addition to diseases affecting the udder, many other diseases of cows adversely affect the quality and quantity of the milk yield, and it is UNPROFITABLE TO THE FARMER TO RETAIN IN HIS HERD ANY ANIMAL WHICH IS NOT ABSOLUTELY HEALTHY.

Grooming of Cows

Unless all the cows of a dairy herd are regularly and thoroughly groomed, it is not possible to produce clean milk consistently. It is unfortunately a fact that many milking cows are allowed to get into an almost incredible state of filthiness. In many cases udders and hindquarters are found caked with dung and dirt and in such a condition as to render it impossible to milk the animal without fouling the milk with dirt.

Whilst it is true that in such extreme cases it is no easy task to cleanse COWS, IT ALSO IS TRUE TO SAY THAT, PROVIDED GROOMING IS REGULAR, THE AMOUNT OF TIME NECESSARY IS ALMOST NEGLIGIBLE.

Where the animal is caked with dirt, the easiest plan is to remove dirt and hair together by means of hand clippers. It is not necessary to clip too large an area, but it is very desirable that the long silky hairs on the udder itself should be kept short as they form an admirable resting-place for dirt. The following figures show the influence of clipping the udder upon the bacterial content of milk :

	Bacteria per ml.
Cows, not groomed, udders not clipped	4,274
Cows' udders clipped	2,505
Cows washed and dried, udders clipped	900

After clipping, cows should be thoroughly groomed with a curry-comb and stiff brush. The udder should afterwards be washed. SLIGHTLY WARM WATER , to which has been added a sufficient quantity of hypochlorite solution (800 parts per million), is most useful for this purpose, although cold water is constantly used by many clean milk producers with no ill-effects. After brushing and washing, the udder should be dried with a cloth kept specially for the purpose, which should be wrung out in cold water before use.

It is not desirable to dry the udder thoroughly, but it is necessary to see that there are no drops of water left which might find their way into the milking pail. One object of washing is to leave the udder slightly damp in order to arrest any particles of dust which may be present, and thus prevent their entry into the milk. Many farmers are strongly opposed to clipping, grooming and washing the udders of cows because they believe that disease of the udder must necessarily follow. This is not so, as is evidenced in the case of many herds throughout the country in which such practices are carried out daily. It is obviously unwise to undertake the operation in a slipshod manner—for instance, by throwing buckets of water over the animal in a similar manner to washing a cart—but where washing is carried out carefully in the manner indicated, no harmful results will follow. It is necessary to wash the udders during the summer period, otherwise the bacterial content of the milk will increase during that time.

On all farms the horse receives careful attention in grooming, great pride being taken in the cleanly condition of these animals. It does not seem unreasonable to ask that the cow should receive similar treatment, more particularly as it produces such an important foodstuff as milk, which is so susceptible to the action of bacteria introduced with dirt.

The grooming of cows is of primary importance, and it has been proved over and over again that failure to carry out this work has resulted in failure to produce clean milk. The production of clean milk depends entirely upon continual attention to details, some of which, considered alone, appear trivial and unimportant, but when taken in conjunction with others assume enormous importance.

Clean Milk Production

ALL MILKING COWS MUST BE THOROUGHLY HEALTHY.

DISEASES OF THE UDDER AFFECT THE QUALITY OF MILK AND ALSO THE YIELD AND MAY BE DANGEROUS TO PUBLIC HEALTH.

IN ORDINARY MASTITIS, THE AFFECTED PART OF THE UDDER IS HOT AND PAINFUL.

IN TUBERCULAR MASTITIS, THE AFFECTED PART IS COLD AND PAINLESS, AND THE MILK MAY APPEAR NORMAL.

ADEQUATE COMPENSATION IS NOW PAID FOR ANIMALS SLAUGHTERED ON ACCOUNT OF TUBERCULOSIS.

THE SALE OF TUBERCULOUS MILK IS NOW A SUMMARY OFFENCE.

DISEASED OR ABNORMAL UDDERS MUST RECEIVE EARLY ATTENTION BY A VETERINARY SURGEON.

GROOMING OF COWS IS ESSENTIAL FOR THE PRODUCTION OF CLEAN MILK.

PROVIDED GROOMING IS REGULAR, THE AMOUNT OF TIME NECESSARY IS ALMOST NEGLIGIBLE.

EFFICIENT GROOMING CONSISTS OF CLIPPING, BRUSHING, AND WASHING.

WASHING THE UDDER IN NO WAY AFFECTS THE HEALTH OF THE ANIMAL OR RESULTS IN A DISEASED UDDER.

GROOMING OF COWS IS ESSENTIAL FOR THE PRODUCTION OF CLEAN MILK

Bulletin No. 4

Suitable for Producers

MILKING TIME

The methods adopted during and immediately after milking are of the utmost importance. IT IS ABSOLUTELY IMPOSSIBLE TO PRODUCE CLEAN MILK REGULARLY UNLESS PROPER METHODS ARE CONSISTENTLY CARRIED OUT AT THE TIME OF MILKING. Many of these details appear of little consequence when studied alone, but collectively they have a considerable bearing upon the cleanliness of milk. It is not too much to say that this period is the most important in the whole series of operations concerned with the production of milk. In the majority of cases of dirty milk, original contamination occurs during the period of milking or immediately after, and before milk is cooled.

Preparation of the Cowshed

Dung should be removed from the cowshed some *considerable time prior* to milking or *after* milking, and on no acccount immediately before such time, as movement of the material causes dissemination of dust and dirt which float in the air and are liable to enter and contaminate milk in the milk-pail.

Preparation of the Cows

Attention must again be drawn to the grooming of the udders and hindquarters of cows which has been dealt with in detail in Bulletin No. 3.

It is sufficient here to repeat that it is IMPOSSIBLE TO PRODUCE CLEAN MILK CONSISTENTLY UNLESS ANIMALS ARE REGULARLY GROOMED and that such grooming, including washing of the udders, in no way affects the health of sound, normal cows.

Wherever possible, animals should not be fed during or immediately before milking. In particular, dusty foods should be avoided as they are liable to produce dust in the atmosphere of the cowshed ; also roots, which, if given before or during milking, are liable to flavour milk and render it objectionable in taste. In the case of restless animals, where difficulty is experienced in keeping them quiet during milking, a little cake will be found useful and may be given without risk of affecting the milk.

Preparation of the Milkers

It is equally important that the PERSONS ENGAGED IN THE ACTUAL OPERATIONS OF MILKING SHOULD BE ABSOLUTELY HEALTHY. It is an offence for any persons to milk cows or handle milk if they are suffering from an infectious disease or if they have been recently in contact with a person so suffering or if they are in such a condition that there is a danger of transmitting any disease. Extensive powers are given to Medical Officers of Health to prohibit the sale of milk or employment of any person where infectious disease is caused or is likely to be caused through the milk supply.

Before commencing milking operations, ALL MILKERS SHOULD WASH THEIR HANDS THOROUGHLY WITH SOAP AND WATER. It is also very desirable that milkers should re-wash their hands between the milking of separate animals. The provision of a clean towel is important. THE IMPORTANCE OF MILKERS BEING HEALTHY AND SCRUPULOUSLY CLEAN CANNOT BE OVER-ESTIMATED.

Clean white overalls should be provided for each milker. This enables dirt to be easily seen on the white cloth, and furthermore fosters a highly desirable spirit of cleanliness among workers. The use of a clean milking cap is also essential. Many farmers complain that they experience great difficulty with their farm hands, who either refuse or consistently neglect to carry out the simplest rules of personal cleanliness. In such cases it is suggested that continual instruction on the part of the farmer will eventually result in the education of the milker and secure his keen co-operation in efforts for the production of clean milk. On farms where the farmer has taken some little trouble with his cowmen and milkers, results have been very gratifying and have amply repaid any time spent in this connection. In any case the production of milk is of such importance as to necessitate continual personal supervision by the farmer himself, and in no case should this work be left entirely to farm hands.

The Milking Stool

The condition of the milking stool is frequently neglected, indeed in many cases it can only be described as filthy, its permanent resting-place appearing to be the dung heap. MILKING STOOLS SHOULD BE WASHED AND SCRUBBED REGULARLY as, during milking operations, any dirt which may lodge on them is readily transferred to the milk.

Method of Milking

ONE OF THE PRIME ESSENTIALS OF CLEAN MILK PRODUCTION IS THAT MILKING MUST BE DRY-HANDED. THE ABOMINABLE AND FILTHY PRACTICE OF WET MILKING CANNOT BE TOO STRONGLY CONDEMNED. The statement that dry-handed milking results in sore teats is incorrect and is not borne out in practice.

It is very important that *the first stream of milk from each teat should be discarded*, as a number of bacteria always find their way some distance up the teat opening, being removed with the first flow of milk. If the first stream of milk is rejected, a marked improvement in the cleanliness of the remainder of the milk will result.

The Milking Pail

The type of milking pail used is of considerable importance. THE COVERED TYPE OF PAIL IS OF MUCH GREATER VALUE THAN THE ORDINARY OPEN BUCKET. The object of the covered pail is to prevent dust falling from above into the milk. Whenever an old type of open pail becomes unfit for use, it is strongly recommended that it be replaced by a covered pail of approved type. By this means the gradual elimination of the open variety will result.

Whenever possible milk from each cow should be removed in a covered pail immediately after milking to the dairy or milkroom. When this is not possible a larger bucket or can capable of holding the milk of four or five cows and provided with a tightly-fitting cover should be used. Pouring milk from one vessel to another in the cowshed should be restricted to a minimum. If milk is poured from vessel to vessel in the cowshed, it is liable to become heavily contaminated by continual exposure to air.

Clean Milk Production—Milking Time

IT IS ESSENTIAL THAT PROPER METHODS BE EMPLOYED AT THE TIME OF MILKING.

DUNG MUST BE REMOVED SOME CONSIDERABLE TIME BEFORE MILKING BEGINS.

IT IS IMPOSSIBLE TO PRODUCE CLEAN MILK CONSISTENTLY UNLESS THE UDDERS AND HINDQUARTERS OF THE COWS ARE REGULARLY GROOMED.

COWS SHOULD NOT BE FED BEFORE OR DURING MILKING.

EVERY PERSON ENGAGED IN MILKING SHOULD BE ABSOLUTELY HEALTHY.

ALL MILKERS SHOULD WASH THEIR HANDS THOROUGHLY WITH SOAP AND WATER.

THE PROVISION OF OVERALLS, INCLUDING CAPS, IS ESSENTIAL.

MILKING STOOLS SHOULD BE WASHED AND SCRUBBED REGULARLY.

DRY-HANDED MILKING MUST BE INSISTED UPON.

THE PRACTICE OF WET-HANDED MILKING CANNOT BE TOO STRONGLY CONDEMNED.

THE FIRST STREAM OF MILK FROM EACH TEAT SHOULD BE DISCARDED.

COVERED MILKING PAILS SHOULD BE USED WHEREVER POSSIBLE.

MILK SHOULD BE REMOVED FROM THE COWSHED TO THE DAIRY AS QUICKLY AS POSSIBLE.

THE CLEANLINESS OF THE MILKER AND OF HIS CLOTHING IS OF THE UTMOST IMPORTANCE

Bulletin No. 5

Suitable for Producers and Distributors

THE DAIRY AND MILKSHOP

The dairy includes any room or place in which milk is kept and any shop from which milk is sold. The condition of the dairy is of the utmost importance and it is essential that the milk should be kept in such a manner as to prevent any risk of it becoming contaminated while it remains on the premises. WHEREVER POSSIBLE, THE DAIRY SHOULD BE KEPT EXCLUSIVELY FOR THE STORAGE OF MILK OR OTHER DAIRY PRODUCTS.

Construction of the Dairy

The following requirements of the dairy apply more particularly to places in which milk is stored and not necessarily to milkshops. The premises should be WELL LIGHTED AND VENTILATED. The floor should be of impervious material, preferably concrete, and wherever possible walls should be rendered in cement to a height of 4 feet 6 inches. The whole of the internal surfaces above the rendering should be limewashed as frequently as is necessary. There should be an adequate supply of WHOLESOME WATER for cooling and washing purposes. There should be no drain inlet in the dairy.

Washing-up Room

Wherever possible, milk utensils should be washed and sterilised in a room apart from the dairy. The washing-up room should be provided with a hot and cold water supply and a proper washing-up sink or tanks, with, if at all possible, facilities for the generation of steam for sterilisation purposes.

Straining of Milk

The provision of an *efficient* strainer is necessary and such strainer should be of the type in which STERILE COTTON-WOOL DISCS are used, each disc being discarded after use. Muslin is not to be recommended because of the difficulty of adequately cleansing and sterilising this material after use. Apart from this, it is not an efficient straining substance. *It is important to remember that straining is only a precautionary measure, and affords no true indication as to the cleanliness of milk.*

Wherever a dairyman finds a large quantity of visible dirt in his milk, he should interview the producer and request that steps be taken to improve methods of production. The consistent supply of dirty milk to a dairyman is sufficient justification for transferring his business elsewhere to a clean milk producer.

Cooling of Milk

EFFICIENT COOLING OF MILK IMMEDIATELY AFTER IT LEAVES THE COW IS OF VITAL IMPORTANCE, inadequate cooling being largely responsible for many cases of early souring.

It has already been explained that action of bacteria is the cause of souring of milk, and these bacteria are most active when temperature is high. The immediate object of cooling milk therefore is to reduce it to such a temperature that the activity of any bacteria which may be present or which may subsquently gain entrance is retarded or prevented.

The wisest plan is for all milk to be COOLED AT THE PLACE OF PRODUCTION. Dairymen will therefore do well to insist that all milk sent to them is cooled before leaving the farm.

The type of cooler is important. It should be capable of reducing the temperature of milk to within 4° or 5° Fahrenheit of the temperature of the cooling water. A final temperature of 40°–45° Fahrenheit is desirable and the provision of some method of refrigeration deserves consideration. The cooler is one of the most difficult items of apparatus to cleanse thoroughly, and it is important that the CORRUGATIONS SHOULD BE SUFFICIENTLY WIDE APART to render this practicable. The cooler should be carefully covered when not in use to protect it from contamination.

Cleansing and Sterilisation of Milk Vessels

THE IMPORTANCE OF THOROUGHLY CLEANSING AND STERILISING ALL MILK VESSELS CANNOT BE OVER-ESTIMATED. The first essential is preliminary rinsing for the removal of traces of old milk, etc. COLD WATER must be used for this purpose. After a thorough rinsing with cold water, the utensils should be washed and scrubbed with hot water to remove any traces of fat which remain. The *outsides* of vessels should also be washed. Utensils should then be STERILISED. STEAM IS BEST FOR THIS PURPOSE, although one of the many approved hypochlorite solutions may be employed if steam is not available. Scalding by means of hot water is not nearly so satisfactory or effective. If scalding is adopted, water BOILING VIGOROUSLY must be applied to every part of a vessel, *including the lid*, for a reasonable length of time.

Sterilisation of milk vessels by means of steam does not necessarily mean the provision of expensive apparatus. An ordinary copper can be adapted for this purpose in a convenient manner. A hole is made in the lid to allow for the escape of steam, and the larger utensils, including churns and pails, are placed directly over this. Exposure for 10 minutes will be sufficient for large churns.

Smaller vessels should be placed in a galvanised tank, say, 2½ × 3½ feet in size, the bottom perforated with 1-inch holes and provided with a detachable lid. When the water in the copper is vigorously boiling, the tank should be placed on the copper, when steam will enter through the perforations. The tank should remain in position, while the water is boiling, for about ten minutes. After vessels have been sterilised, great care should be taken to ensure that they are protected from contamination until required again. The practice of leaving sterilised milk churns and cans exposed to the atmosphere cannot be too strongly condemned.

The Milkshop

Milk should only be kept and sold in shops where a purely dairy business is carried on. The practice of selling milk in shops where goods of a non-dairy character are also sold, and which are liable to affect milk adversely by the dissemination of dust or effluvia, is to be discouraged, unless the milk is sold in the same *unopened* receptacle in which it has been delivered to the premises. Milk for sale in a dairy should be kept in a clean vessel, carefully protected from all possible sources of contamination and from the influence of heat.

Clean Milk Distribution—The Dairy

THE DAIRY SHOULD BE KEPT THOROUGHLY CLEAN AND IN GOOD ORDER.

THE DAIRY SHOULD BE USED EXCLUSIVELY FOR THE STORAGE OF MILK.

THE DAIRY SHOULD BE WELL-LIGHTED AND VENTILATED.

THE MILK ROOM SHOULD BE LIMEWASHED AS OFTEN AS NECESSARY.

THERE SHOULD BE NO DRAIN INLET IN THE DAIRY.

ALL MILK SHOULD BE STRAINED THROUGH AN EFFICIENT STRAINER.

STERILE COTTON-WOOL DISCS ARE THE BEST ARTICLES FOR STRAINING PURPOSES.

DAIRYMEN SHOULD INSIST THAT ALL MILK SENT TO THEM BY THE PRODUCER IS "CLEAN MILK."

EFFICIENT COOLING OF MILK IMMEDIATELY IT LEAVES THE COW IS OF VITAL IMPORTANCE.

THE MILK COOLER SHOULD BE CAPABLE OF BEING EASILY AND EFFICIENTLY CLEANSED AND STERILISED.

ALL MILK VESSELS MUST BE THOROUGHLY CLEANSED AND STERILISED IMMEDIATELY AFTER USE.

STEAM IS THE ONLY EFFICIENT MEANS OF STERILISATION.

THE USE OF STEAM DOES NOT NECESSARILY INVOLVE THE PROVISION OF EXPENSIVE APPARATUS.

MILKSHOPS SHOULD BE USED EXCLUSIVELY FOR THE CONDUCT OF PURELY DAIRY BUSINESSES.

THE COOLING OF ALL MILK AND THE STERILISATION BY STEAM OF ALL MILK VESSELS IS OF THE UTMOST IMPORTANCE

Bulletin No. 6

Suitable for Producers and Distributors

TRANSIT AND DISTRIBUTION OF MILK

Milk may be distributed by rail, by road, or by hand, and in each case there are many ways in which it may become contaminated. It must be emphasised, therefore, that, however careful the methods adopted at the place of production have been, these efforts will be very largely wasted if CARE IS NOT TAKEN TO SAFEGUARD MILK FROM CONTAMINATION DURING TRANSIT AND DISTRIBUTION TO THE CONSUMER.

Milk Churns

Considerable care and attention is necessary in the case of milk churns used for the transport of milk. The interiors of churns should be smooth and free from seams, etc., which are liable to collect dust and dirt. Churns are available which are constructed in one piece without seams. One of the most important parts of the milk churn is the LID. The lid acts as a means of protecting milk from contamination and also prevents wastage of milk through spilling. Many older types of churn are provided with lids having holes for ventilation purposes. These have been found to be quite unnecessary, and, in fact, very undesirable since they considerably increase the risk of dirt, etc., entering and contaminating the liquid. VENTILATED CHURNS DO NOT ASSIST THE KEEPING QUALITY OF CLEAN MILK. A type of churn can be procured in which an inner disc is provided which entirely prevents contamination due to entrance of dust and dirt and also prevents loss of milk due to spilling. The 10 to 12-gallon milk churn is the most suitable size.

Milk Cans, Bottles, and Smaller Receptacles

The remarks with regard to churns apply with equal force to milk cans, bottles, measures, and other small receptacles. These articles should be of such material and so constructed as to allow of ready cleansing, while the interiors should be smooth and free from seams. They should be provided with tightly-fitting covers wherever possible. Cleansing and sterilisation of milk churns and other vessels has already been dealt with, but the importance of these processes being carried out efficiently must again be emphasised.

Transit of Milk by Road or Rail

Churns or other receptacles used to forward milk by road or rail must have the name and address of the owner clearly marked upon them and must be provided with *lids without openings*, so fitted as to prevent access of dust, dirt, etc. Except in certain cases, no milk may be removed from a milk churn or a milk churn opened at a railway station or in a railway van.

Distribution of Milk by Road

Considerable care is necessary in the distribution of milk by road, on account of the fact that, where milk is not conveyed in sealed glass bottles, it is liable to contamination by dust, dirt, etc., every time the churn is opened for the removal of a quantity of its contents. The large churn in which milk is contained in a milk float should be provided with a tightly-fitting cover and should only be opened for the removal of milk. The practice of leaving the lid of a churn off for some time while several customers are supplied with milk is contrary to all public health principles.

Measures used to remove milk should always be kept *inside* the churn. If they are not so kept, they are liable to collect dust and dirt, and the next time they are placed in the milk they will contaminate and spoil the entire supply. *The practice of smoking, which is occasionally indulged in by persons delivering milk, is very undesirable.* It has been observed in such cases that tobacco ash and dust drop into the liquid. It is very important that persons delivering milk should realise the delicate nature of the food which they are handling, and they should appreciate the absolute need for all precautions necessary to prevent contamination.

The Milk Float or Van

The vehicle used for conveyance of milk must be kept thoroughly clean, and no live animals or other article likely to give rise to contamination must be conveyed at the same time as milk is being carried. If at any time the vehicle is used for the conveyance of offensive matter it must be thoroughly cleansed before again being used for the conveyance of milk.

Distribution of Milk in Cans by Hand

A certain proportion of milk is distributed by hand, and here again certain precautions are necessary to prevent contamination. Cans used to convey milk should be provided with tightly-fitting covers *which should always be kept in position. Particular attention must be drawn to the practice of leaving small cans standing on the pavement in such a position as to permit of dogs and cats having access to the milk.* This frequently leads to the liquid being fouled and is a particularly objectionable practice.

Distribution of Milk in Bottles

This is the ideal method of distributing milk, and is becoming increasingly popular. Clean, cooled milk, bottled either at the place of production or at the dairy, can be distributed to the consumer with very little fear of contamination. Care should be taken to ensure that discs fit accurately and tightly into the necks of the bottles. Discs should be well waxed to prevent absorption of the liquid. Metal caps are, however, more satisfactory for the sealing of bottles.

The practice of placing milk into bottles in the street is not permitted.

Health of the Workers Employed in Handling or Distributing Milk

It is of the utmost importance that every person engaged in the handling or distribution of milk should be ABSOLUTELY HEALTHY. It is the duty of any person suffering from an infectious disease or who has been in contact with such a case and who is employed by a cowkeeper or dairyman to notify his employer, who in turn must immediately notify the Medical Officer of Heath of the district. The employment of any person likely to spread infection or contaminate milk may be prohibited.

Clean Milk Distribution—The Distribution of Milk

THE VALUE OF THE PRODUCTION OF CLEAN MILK IS VERY LARGELY WASTED IF THE MILK IS NOT PROTECTED FROM CONTAMINATION DURING DISTRIBUTION.

MILK CHURNS SHOULD BE SMOOTH AND SEAMLESS.

MILK CHURNS SHOULD BE PROVIDED WITH TIGHTLY FITTING LIDS, WITHOUT OPENINGS.

VENTILATED CHURN LIDS DO NOT ASSIST THE KEEPING QUALITY OF CLEAN MILK.

MILK CANS AND SMALLER RECEPTACLES SHOULD BE CAPABLE OF BEING EASILY CLEANSED.

ADEQUATE CLEANSING AND STERILISATION OF MILK VESSELS IS ESSENTIAL IF MILK IS TO REMAIN SWEET AND FRESH.

THE PRACTICE OF SMOKING WHILST DELIVERING MILK IS TO BE CONDEMNED.

THE MILK FLOAT MUST BE KEPT THOROUGHLY CLEAN AND ONLY USED FOR THE CONVEYANCE OF MILK.

MILK DELIVERED BY HAND SHOULD BE KEPT IN CLOSED RECEPTACLES.

THE PRACTICE OF LEAVING SMALL CANS CONTAINING MILK ON THE PAVEMENT WITHIN REACH OF DOGS AND CATS IS VERY UNDESIRABLE.

THE DISTRIBUTION OF MILK IN BOTTLES IS THE MOST SATISFACTORY METHOD.

PERSONS COMING INTO CONTACT WITH MILK SHOULD BE ABSOLUTELY HEALTHY.

VESSELS CONTAINING MILK SHOULD HAVE TIGHTLY FITTING COVERS

Bulletin No. 7

Suitable for Consumers

CARE OF MILK IN THE HOME

Milk is one of the most important and useful foods in existence as it is an almost perfect food for infants, being liquid and containing those substances required to build up the body. Because it is a liquid and contains those important substances, it is a most delicate article, easily contaminated and turned sour.

Milk may turn sour and become dangerous to those who consume it because of the action of GERMS or BACTERIA. These germs, although they may be very harmful, are so small that they cannot be seen by the naked eye. In fact, it requires over 25,000 of them to stretch across a halfpenny piece. This will convey some idea of their extremely small size. Germs, like human beings, are alive, requiring food to live. They thrive and multiply best in foods like milk, because of the properties mentioned above.

In order to keep milk sweet for a reasonable length of time and so obtain the greatest advantage from it, the liquid must be protected in such a way that harmful germs do not obtain entrance. This means that the farmer must exercise great care in producing milk on the farm. He has to keep the cows, cowsheds, and all utensils which come into contact with the liquid thoroughly clean. If he does this, he is able to supply health-giving milk to the public which will keep sweet, even in the hottest days of summer.

Milk should always be cold when received from the milkman. *It is very unwise to ask for "warm milk."* The warmer milk is, the more suitable does it become for the growth and multiplication of germs.

Unless milk is carefully stored in the home, it will quickly turn sour and be useless, however clean and sweet it is when delivered by the milkman, firstly because germs may enter the milk through the agency of flies, etc., and secondly because there are always some germs in milk which, under favourable conditions, multiply very rapidly.

ALL PERSONS SHOULD SEE THAT SPECIAL ATTENTION IS CONSISTENTLY PAID TO THE CARE OF MILK IN THEIR HOMES. In the first place, the MILK VESSEL SHOULD BE QUITE CLEAN BEFORE the milkman puts fresh milk into it. If the milk vessel is left on the doorstep, it should be carefully covered, in order to keep it clean and protect it from contamination. It should also be stored in a COOL PLACE. It should never be placed near fireplaces, gas-stoves, cookers or gas-boilers, or any other place where it is likely to become warm. Germs always thrive and flourish best in warm places. In summer milk vessels should stand in a bowl of fresh cold water, in order to keep the milk as cool as possible. The milk vessel should always be COVERED. This is necessary to prevent contamination by dust and to prevent flies, which carry many germs on their bodies, having access to milk. Milk should never be placed near any article or food-stuff which has a *strong smell*, particularly fish, because it is likely to absorb the smell and become objectionable to the palate.

The milk vessel should be washed out *immediately after use.* It should first be washed out with cold water to remove any traces of old milk and then be scalded with BOILING WATER to sterilise the whole vessel. After that is done, it should be kept covered until required again. When milk is required for use, it should be removed from the milk vessel, but only in sufficient quantities for immediate requirements. Any milk left over should never be poured back into the original fresh milk vessel because, if it has become contaminated, this will render the whole of the milk unfit for use.

Always remember that milk is the most delicate article of food in use in the home, requiring the greatest care and attention. If the suggestions made in this Bulletin are carried out, there should be no difficulty in keeping milk fresh for any reasonable length of time.

If you carry out these recommendations *regularly and consistently* and still your milk does not keep as long as you think it ought to, consult your local sanitary inspector who will endeavour to find out the cause and have it remedied

Care of Milk in the Home—Remember:

· Milk is a most useful and important food which is easily contaminated.

Milk turns sour and becomes dangerous when germs gain access to it.

Germs thrive in warmth, therefore keep your milk in a cool place.

Always cover your milk vessel and keep it scrupulously clean.

Wash your milk vessel immediately after use with cold water, followed by scalding.

Never pour unused milk back into the original fresh milk vessel.

These precautions are of the utmost importance and must be carried out, not sometimes, but always.

The **RIGHT WAY** means:

A CLEAN MILK VESSEL
KEPT IN A COOL PLACE
AND ALWAYS COVERED

APPENDIX III

INSPECTION REPORT CARD

	Maximum Allocation of Marks					Marks Awarded
	Producer –Retailer	Producer –Wholesaler	Cheese-making Farms	Butter-making Farms	Open-air Dairies	
EQUIPMENT *Food and Water* (6)						
Food—Clean and wholesome	2	2	2	2	2	
Water: Clean and fresh	2	2	2	2	2	
Convenient and abundant	2	2	2	2	2	
	4	4	4	4	4	
Accommodation for Cows at Milking Time (32)						
Location: well drained	1	1	1	1	4	
Free from contaminating surroundings	1	1	1	1	8	
	2	2	2	2	12	
Construction: impervious floor	3	3	3	3	—	
Raised standing space	3	3	3	3	—	
Efficient gutters and suitable outlets	3	3	3	3	—	
Impervious walls and easily cleaned ceiling or roof	2	2	2	2	—	
Proper stall and manger	1	1	1	1	—	
	12	12	12	12	—	
Provision for light and ventilation:						
Sufficiency[1] of light	5	5	5	5	—	
Sufficiency[1] of ventilation	5	5	5	5	—	
	10	10	10	10	—	
Facilities for cleansing:						
Water supply for washing stalls, gangways, gutters, etc.	2	2	2	2	—	
Equipment for washing milkers' hands	3	3	3	3	4	
Equipment for washing and cleaning cows' udders	3	3	3	3	4	
Provision of clean water for washing udders and hands	—	—	—	—	12	
	8	8	8	8	20	
Accommodation for Handling Milk (13)[2]						
Location: free from contaminating surroundings	3	3	3	3	3	

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[1] Sufficiency implies (1) the ability to see clearly in all parts of the cowshed during milking, and (2) that the air is pure.

[2] Where dairies are run on the "Hosier" system, these marks should be allocated to "General protection of milk from contamination during handling."

	Maximum Allocation of Marks					Marks Awarded
	Producer –Retailer	Producer –Wholesaler	Cheese-making Farms	Butter-making Farms	Open-air Dairies	
Construction:						
Impervious floor and outside drainage	4	4	4	4	4	
Impervious walls and suitable ceiling or roof	3	3	3	3	3	
Adequate light and ventilation	3	3	3	3	3	
	10	10	10	10	10	
Utensils (49) (39)						
Construction and state of repair:						
Milking pails	6	6	6	6	6	
Strainer and straining material (metal gauze alone, 0)	2	2	2	2	2	
Cooler and protection of cooler	4	4	—	—	4	
Equipment for filling and sealing milk bottles	2	—	—	—	7	
Delivery vessels (glass bottles, max.)	5	—	—	—		
Delivery churns, type	—	2	—	—		
Delivery churns, condition	—	5	—	—		
Cheese vat or separator or setting pans	—	—	4	4	—	
Moulds or cream-ripening vessels	—	—	1	1	—	
Presses or butter churn	—	—	1	1	—	
	19	19	14	14	19	
Facilities for cleansing:						
Separate boiler-house	2	2	2	2	2	
Separate room for washing utensils	2	2	2	2	2	
Adequate supply of clean water	4	4	4	4	4	
Steam	10	10	8	8	10	
Sterilising equipment (steam chest, max.)	7	7	4	4	7	
Other equipment	2	2	2	2	2	
	27	27	22	22	27	
Milking suits and caps	3	3	3	3	3	
Press Room (5)						
Impervious floor and outside drainage	—	—	1	—	—	
Impervious walls and suitable ceiling or roof	—	—	1	—	—	
Adequate light and ventilation	—	—	1	—	—	
Control of temperature	—	—	2	—	—	
	—	—	5	—	—	
Ripening Room (5)						
Control of temperature and humidity	—	—	5	—	—	
Cream and Butter Storage Room (10)	—	—	—	10	—	
	100	100	100	100	100	
METHODS						
Cows (75)						
General cleanliness (free from obvious dirt, 10)	15	15	15	15	15	

	Maximum Allocation of Marks					Marks Awarded
	Producer -Retailer	Producer -Wholesaler	Cheese-making Farms	Butter-making Farms	Open-air Dairies	
Cleaning, preparatory to milking (deduct points according to failure to clean thoroughly) .	30	30	30	30	30	
Frequency with which washing water and cloth are changed . .	10	10	10	10	10	
Shortness of hair on and around udders (12) ; flanks and tail (8).	20	20	20	20	20	
	60	60	60	60	60	
Cowsheds or Corresponding Accommodation (28)						
Cleanliness :						
Floor (soiled bedding absent during milking time, max.) . .	4	4	4	4	18	
Walls and partitions . . .	2	2	2	2		
Roofs, rafters, and ledges . .	3	3	3	3		
Mangers and troughs . . .	1	1	1	1		
Windows and artificial lights .	3	3	3	3		
	13	13	13	13	18	
Adjacent Yards :—						
Cleanliness	4	4	4	4	—	
Condition of drains . . .	2	2	2	2	—	
	6	6	6	6	—	
Air at Milking Time :						
Freedom from dust . . .	6	6	6	6	10	
Freedom from flies . . .	3	3	3	3		
	9	9	9	9	10	
Milkroom (35) *or Cheese-making Press and Storing Rooms, or Butter-making, Cream-ripening and Storage Rooms* (50).						
Cleanliness of :						
Floor	2	2	5	5	2	
Walls and roof	8	8	8	8	8	
Freedom from dust and flies .	10	10	15	15	10	
Used solely for dairying purposes.	8	8	10	10	8	
Cheese shelves or butter slabs .	—	—	5	5	—	
	28	28	43	43	28	
Adjacent Yards :						
Cleanliness	5	5	5	5	5	
Condition of drains . . .	2	2	2	2	2	
	7	7	7	7	7	
Utensils (125) (100)						
Care and Cleanliness :						
(Thoroughly washed and sterilised in a chest at 210° F. for 20 minutes, max. Thoroughly washed and steamed with jet only, deduct 5 ; thoroughly washed and scalded only, deduct 10.)						
Milking pails, max.	15	15	15	15	15	
Strainer, max.	15	15	15	15	15	

	Maximum Allocation of Marks					Marks Awarded
	Producer –Retailer	Producer –Wholesaler	Cheese-making Farms	Butter-making Farms	Open-air Dairies	
Cooler, max.	15	15	—	—	15	
Milk or cream-ripening vessels, max.	—	—	5	10	—	
Transit vessels, max.	25	25	—	—	25	
Vat or separator or cream-raising pans, max.	—	—	10	10	—	
Other equipment, including cloths, max.	5	5	5	5	5	
Bottling machine, max.	10	—	—	—	10	
Storage and management of churns	—	10	—	—		
Moulds and presses or butter churn and worker	—	—	10	10	—	
Protection from contamination of all utensils	25	25	25	20	25	
Cleanliness of milking stools and straps	15	15	15	15	15	
	125	125	100	100	125	
Milking (55)						
Care and Cleanliness:						
Cleanliness of milkers (clean suits, caps, etc.)	10	10	10	10	10	
[1] Manner of milking (clean dry hands essential for max.) —	20	20	20	20	20	
[1] Use of covered milking pails	15	15	15	15	15	
Method of discarding fore-milk (discarding into separate pail, 10; on the floor, 5)	10	10	10	10	10	
	55	55	55	55	55	
Handling Milk (82) (92)						
Cleanliness of attendants in milk room or dairy	5	5	5	5	5	
Milk removed immediately to milk room without pouring from pail (if poured into carrying can in cowshed, max. 8)	10	10	10	10	—	
Protection from contamination during removal to milk room	5	5	5	5	15	
Efficient straining	2	2	2	2	2	
Cooling (see note 2)—cooled to within 5° F. of the temperature of the water supply—30. For each degree to which milk is cooled below 60° F. down to 45° F. award 1 mark. This gives a total maximum of 45 marks. For each degree in excess of a temperature of 5° F. above that of the water supply deduct 5 points	45	45	—	—	45	
Management of evening's milk in the dairy						
Accuracy of thermometer	—	—	25	—	—	
Method of obtaining cream; or	—	—	10	10	—	

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[1] Where milking machines are in use, the marks under these readings should be allocated to "Facilities for cleansing and for keeping milk clean."

	Maximum Allocation of Marks					Marks Awarded
	Producer –Retailer	Producer –Wholesaler	Cheese-making Farms	Butter-making Farms	Open-air Dairies	
method of scalding cream (hot water 15; direct heat 5)	—	—	—	15	—	
Management of milk prior to renneting	—	—	10	—	—	
Management of cream prior to churning	—	—	—	20	—	
Method of making and storing starter	—	—	25	25	—	
Method of filling and securing bottles or churns	5	5	—	—	5	
Management of milk prior to delivery	10	10	—	—	10	
	82	82	92	92	82	
Total	400	400	400	400	400	

Equipment................per cent. Methods................per cent.

Note 1. If any exceptionally filthy condition is found, such as dirty milking pails, strainer, cooler, transit vessels, etc., the total score may be further limited.

Note 2. Where the sale of uncooled milk is generally practised the marks allotted to the cooler and cooling (max. 64) should be awarded in proportion to those given for the remainder of *Equipment* and *Methods*. From the marks awarded, a deduction of 10 in winter months or 25 in summer months should be made as a penalty for not cooling.

Note 3. This Appendix is reproduced by permission of the Controller of His Majesty's Stationery Office, from the *Ministry of Agriculture and Fisheries Bulletin*, No. 46, 1934, fifth edition, Appendix V.

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